7.1 Hanford Groundwater Monitoring Project
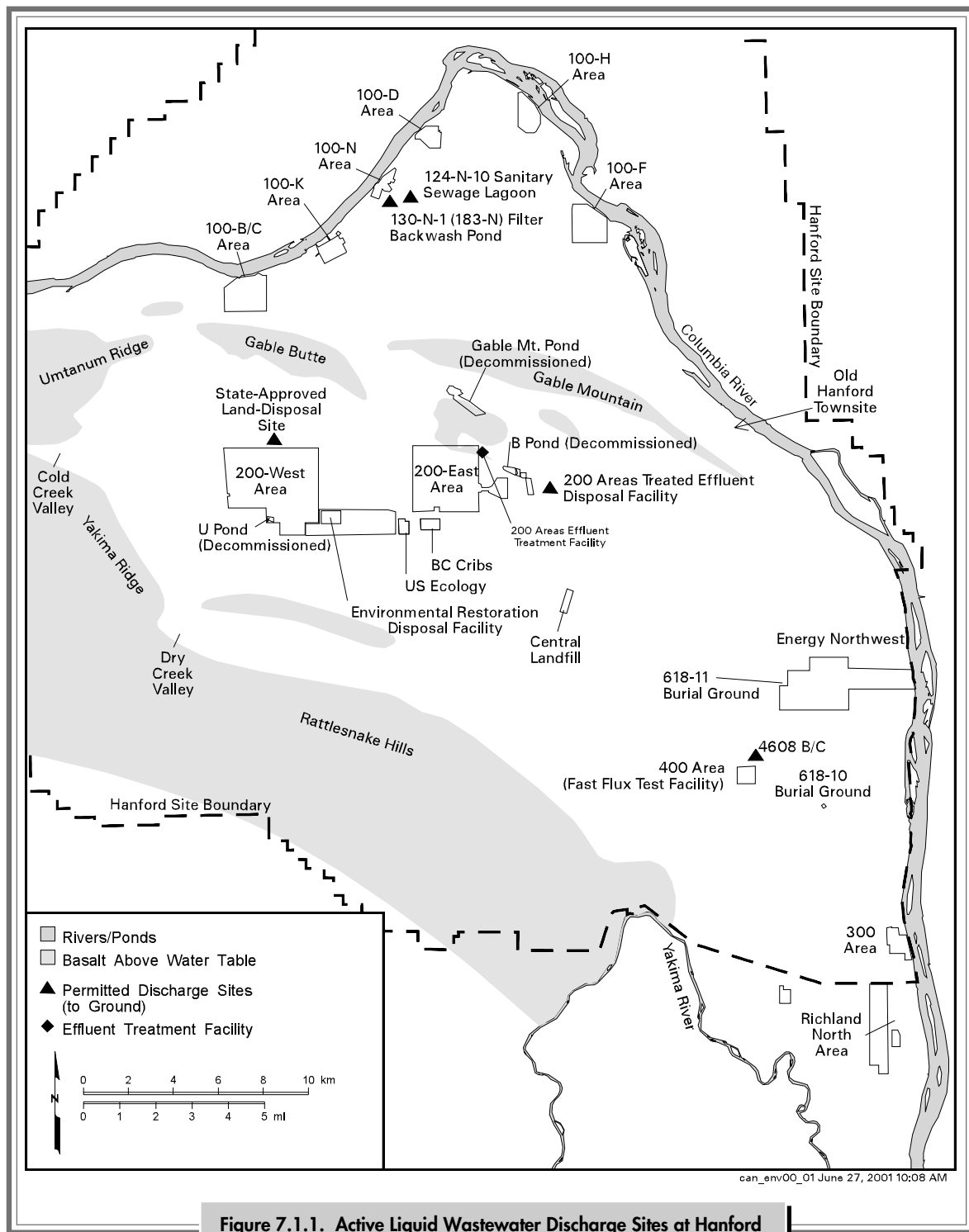
D. R. Newcomer and M. J. Hartman

The strategy for managing and protecting groundwater resources at the Hanford Site focuses on protection of the Columbia River, human health, the environment, treatment of groundwater contamination, and limitation of contaminant migration from the 200 Areas (see Groundwater/Vadose Zone Integration Project reports DOE/RL-98-48 and DOE/RL-98-56). To implement this strategy, the Hanford Groundwater Monitoring Project continues to monitor the quality of groundwater. The project, which is conducted by Pacific Northwest National Laboratory for DOE, is designed to detect and characterize new contaminant plumes and to document the distribution and movement of existing groundwater contamination. Monitoring provides the historical baseline to evaluate current and future risk from exposure to groundwater contamination and to decide on remedial options. Hydrogeologic studies are an integral part of the project because the geology and hydrology of the Hanford Site control the movement of contaminants in groundwater.
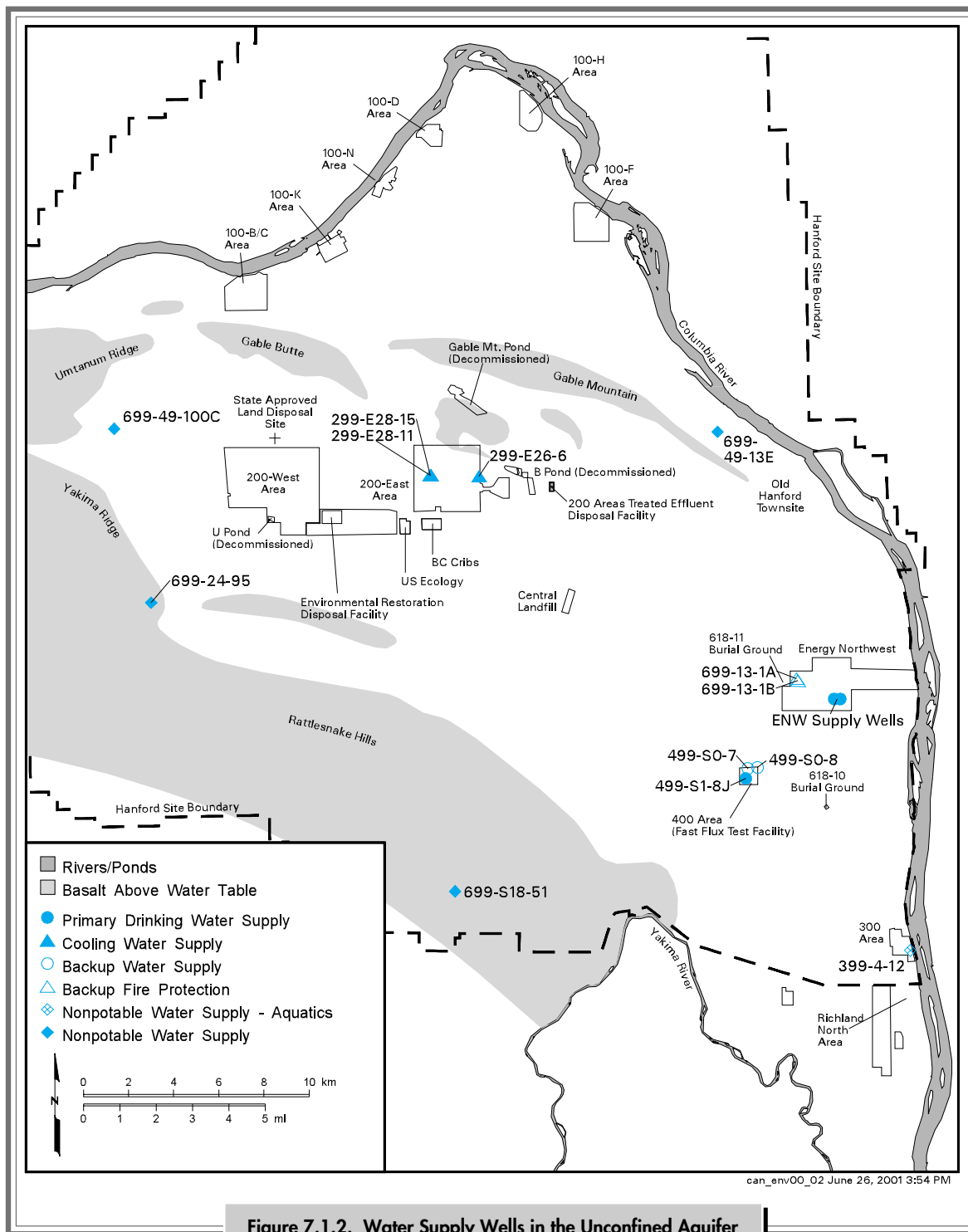
The effort to protect groundwater quality at the Hanford Site is implemented through programs to minimize and eliminate waste discharged to the soil column and through remediation work on the site. The Hanford Federal Facility Agreement and Consent Order (also known as the Tri-Party Agreement; Ecology et al. 1998) provided a framework for remediation of the Hanford Site, including groundwater, over a 40-year period. A summary of accomplishments in waste minimization and site remediation is presented in Section 2.3.

DOE prepared a *Plan and Schedule to Discontinue Disposal of Liquids Into the Soil Column at the* *Hanford Site* (DOE 1987), which includes an alternative to treat and dispose contaminated effluents discharged to the soil. Of the 33 major waste streams identified in DOE (1987), the Phase I (high-priority) streams have either been eliminated or are being treated and diverted to the 200 Areas Treated Effluent Disposal Facility. In 2000, the State-Approved Land Disposal Site was the only place on the Hanford Site where liquid effluent containing radionuclide contamination (tritium) discharged to the soil column. The locations of active permitted facilities through which wastewater was discharged to the ground in 2000 are shown in Figures 1.3 and 7.1.1 and are discussed in detail in Section 2.3. In 2000, ~3% of the total volume of wastewater at the Hanford Site was discharged to the State-Approved Land Disposal Site and ~97% was discharged to the 200 Areas Treated Effluent Disposal Facility. All other facilities (e.g., cribs, trenches) where wastewater was historically discharged to the soil column are out of service. The only operational injection wells are associated with pump-and-treat remediation systems. Treated wastewater is re-injected into the unconfined aquifer at these wells.

Groundwater is used for drinking water and other purposes at some facilities on the Hanford Site. Pacific Northwest National Laboratory monitors DOE drinking water supplies for radiological constituents at the source and in one instance, at the point of use. Results of the radiological monitoring are summarized in Section 4.3. The locations of wells completed in the unconfined aquifer that provide water for drinking, fire suppression, and cooling are shown in Figure 7.1.2.

Figure 7.1.1. Active Liquid Wastewater Discharge Sites at Hanford

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100-H
Area

100-D
Area

100-N
Area

100-K
Area

100-F
Area

100-B/C
Area

Hanford Site Boundary

Columbia River

Umtanum Ridge

Gable Butte

Gable Mt. Pond
(Decommissioned)

Gable Mountain

699-49-100C

State Approved
Land Disposal
Site

299-E28-15
299-E28-11

299-E26-6

B Pond (Decommissioned)

699-
49-13E

Old
Hanford
Townsite

Yakima Ridge

200-West
Area

200-East
Area

200 Areas Treated Effluent
Disposal Facility

U Pond
(Decommissioned)

BC Cribs

US Ecology

699-24-95

Environmental Restoration
Disposal Facility

Central
Landfill

618-11
Burial Ground

Energy Northwest

699-13-1A
699-13-1B

ENW Supply Wells

Rattlesnake Hills

499-SO-7

499-SO-8

499-S1-8J

618-10
Burial Ground

Hanford Site Boundary

400 Area
(Fast Flux Test Facility)

Rivers/Ponds

Basalt Above Water Table

● Primary Drinking Water Supply

▲ Cooling Water Supply

○ Backup Water Supply

△ Backup Fire Protection

◈ Nonpotable Water Supply - Aquatics

◆ Nonpotable Water Supply

699-S18-51

Yakima River

300
Area

399-4-12

Richland
North
Area

0   2   4   6   8   10 km

0   1   2   3   4   5 ml

N

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Figure 7.1.2. Water Supply Wells in the Unconfined Aquifer

7.1.1 Geologic Setting

The Hanford Site lies within the Pasco Basin, one of several structural basins within the Columbia Plateau. Principal geologic units beneath the Hanford Site include, in ascending order, the Columbia River Basalt Group, the Ringold Formation, and the Hanford formation (informal name) (Figure 7.1.3).

The Columbia River basalts were formed from lava that periodically erupted from volcanic fissures. The regional river system eroded the basalt and deposited sediment across the basalt surfaces between eruptions. Zones between the basalt flows and the sediment deposited as interbeds between basalt eruptions are frequently zones that are used as water sources in areas around the Hanford Site.

During the period when basalt was deposited, tectonic pressure was slowly deforming the basalt flows into the generally east-west ridges that border the Pasco Basin today. After the last major basalt eruption, sand and gravel of the Ringold Formation were deposited in the central portion of the Pasco Basin by the ancestral Columbia River as it meandered back and forth across the relatively flat basalt surface. Following uplift of the basalts and overlying sediment, the Columbia River began to erode, rather than deposit, sediment in the Pasco Basin. The uppermost mud layer was eroded from much of the Pasco Basin, and a caliche layer, part of the Plio-Pleistocene unit, developed in places on the eroded surface of the Ringold Formation. The caliche forms a low-permeability layer that affects migration of water through the vadose zone.

More recently, Hanford formation sediment was deposited by catastrophic ice age floods. Fine sand and silt were deposited in slackwater areas at the margins of the basin. However, primarily sands and gravels were deposited on the Hanford Site. In
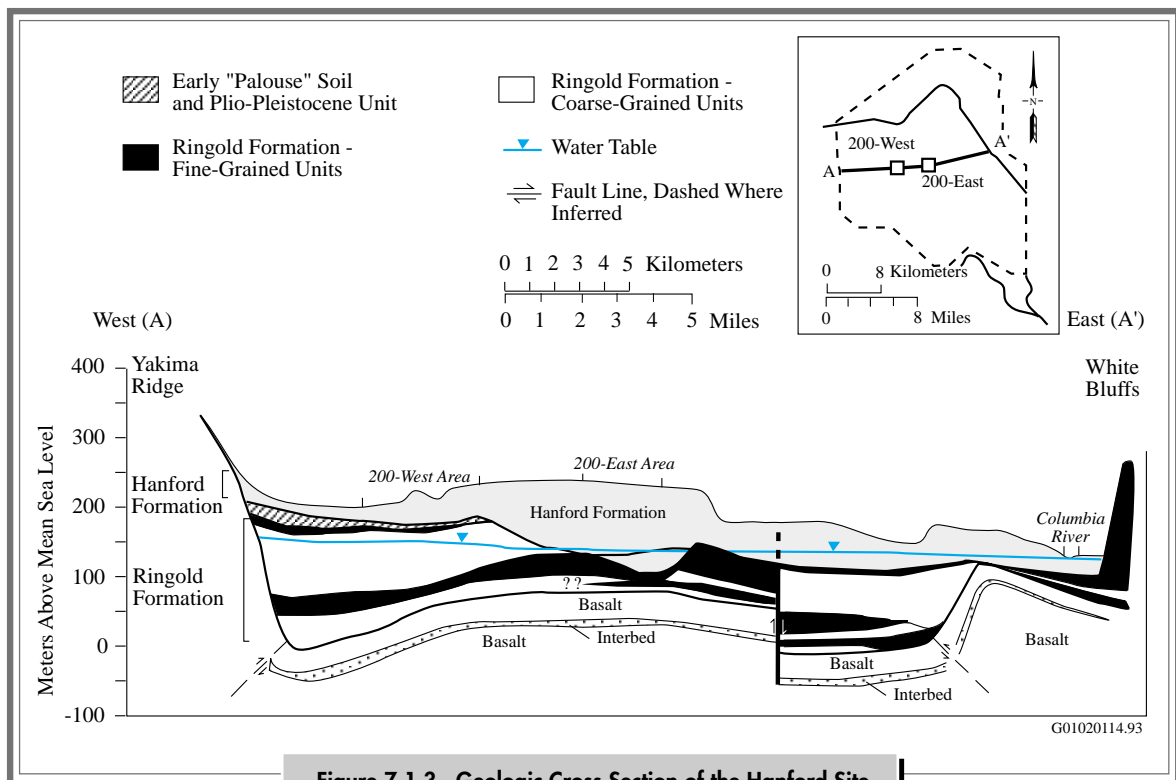

Figure 7.1.3. Geologic Cross Section of the Hanford Site

places, the sediment is covered by up to a few meters of recent stream or windblown deposits.

Detailed information on the geology of the Pasco Basin can be found in BHI-00184, DOE/RW-0164 (Vol. 1), PNNL-13080, WHC-MR-0391, WHC-SD-EN-TI-014, and WHC-SD-EN-TI-019.

7.1.2 Groundwater Hydrology

Both confined and unconfined aquifers are present beneath the Hanford Site. An aquifer is a water-saturated geologic interval or unit that has a high permeability, meaning it can transmit significant quantities of water. A confined aquifer is bounded above and below by low-permeability materials that restrict the vertical movement of water. The confining layers may be dense rock, such as the central parts of basalt flows, silt, clay, or well-cemented sediment (i.e., caliche). Extensive, confined aquifers at the site are found primarily within interflows and interbeds of the Columbia River basalts. These are referred to as basalt-confined aquifers. Locally confined aquifers also are found below the clays and silts of the Ringold Formation.

An unconfined aquifer, or water-table aquifer, is overlain by unsaturated sediment. The upper surface of the saturated zone in an unconfined aquifer, which is called the water table, rises and falls in response to changes in the volume of water stored in the aquifer. In general, the unconfined aquifer at the Hanford Site is located in the Hanford and Ringold Formations. In some areas, the water table is below the bottom of the Hanford formation and the unconfined aquifer is entirely within the Ringold Formation. Sand and gravel of the Hanford formation are unconsolidated and are generally much more permeable than the compacted and silty gravel of the Ringold Formation. Clay and silt units and zones of natural cementation form low-permeability zones within the Ringold Formation.

The unconfined aquifer, which forms the uppermost groundwater zone, has been directly affected by wastewater disposal at the Hanford Site. The unconfined aquifer discharges primarily into the Columbia River and is the most thoroughly monitored aquifer beneath the site. The Rattlesnake Ridge interbed is the uppermost, basalt-confined aquifer within the Pasco Basin and the Hanford Site. This aquifer and other confined aquifers are generally isolated from the unconfined aquifer by dense rock that forms the interior of the basalt flows. However, interflow between the unconfined aquifer and the basalt-confined aquifer system is known to occur at faults that bring a water bearing interbed in contact with other sediments or where the overlying basalt has been eroded to reveal an interbed (Newcomb et al. 1972; RHO-RE-ST-12 P; WHC-MR-0391). Additional information on the basalt-confined aquifer system can be found in PNL-10158 and PNL-10817.

The thickness of saturated sediment above the basalt bedrock is greater than 200 meters (656 feet) in some areas of the Hanford Site and thins out along the flanks of the uplifted basalt ridges (Figures 7.1.3 and 7.1.4). Depth from the ground surface to the water table ranges from less than 0.3 meter (1 foot) near the Columbia River to greater than 106 meters (348 feet) in the center of the site. The unconfined aquifer is bounded below either by the basalt surface or, in places, by relatively impervious clays and silts within the Ringold Formation. The water table defines the upper boundary of the

Figure 7.1.4. Saturated Thickness of the Unconfined Aquifer
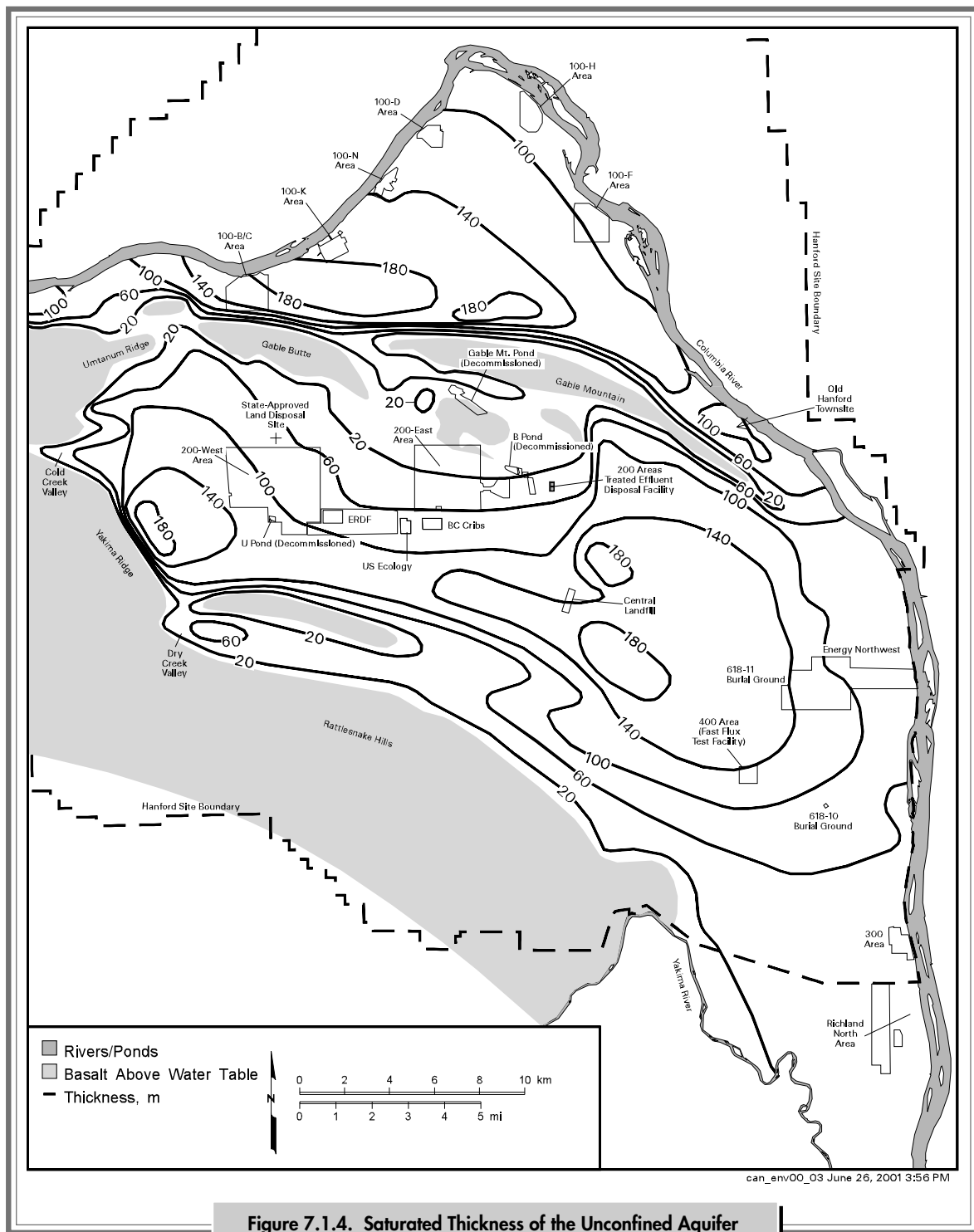
unconfined aquifer. Laterally, the unconfined aquifer is bounded by basalt ridges and by the Yakima and Columbia Rivers. The basalt ridges have a low permeability and act as a barrier to the lateral flow of groundwater where they rise above the water table (RHO-BWI-ST-5, p. II-116).

7.1.2.1 Groundwater Flow

The water-table elevation contours shown in Figure 7.1.5 indicate the direction of groundwater flow and the magnitude of the hydraulic gradient in the unconfined aquifer. Groundwater flow is generally perpendicular to the water-table contours from areas of higher elevation to areas of lower elevation. Areas where the contours are closer together are high-gradient areas, where the "driving force" for groundwater flow is greater. However, because sediment with low permeability inhibits groundwater flow, producing steeper gradients, a high gradient does not necessarily mean high groundwater velocity. Lower transmissivity and steeper gradients are often associated with areas where the water table is below the bottom of the Hanford formation and the aquifer is entirely within the less permeable Ringold sediment. Figure 7.1.6 shows the generalized distribution of transmissivity as determined from aquifer pumping tests and groundwater flow model calibration. Additional information on aquifer hydraulic properties at Hanford is presented in DOE/RW-0164 (Vol. 2) and PNL-8337.

Recharge of water within the unconfined aquifer (RHO-ST-42) comes from several sources. Natural recharge occurs from infiltration of precipitation along the mountain fronts, runoff from intermittent streams such as Cold and Dry Creeks on the western margin of the site, and limited infiltration of precipitation on the site. The Yakima River, where it flows along the southern boundary of the site, also recharges the unconfined aquifer. The Columbia River is the primary discharge area for the unconfined aquifer. However, the Columbia River also recharges the unconfined aquifer for short

periods during high-river stage, when river water is transferred into the aquifer along the riverbank. Recharge from infiltration of precipitation is highly variable on the Hanford Site both spatially and temporally. The rate of natural recharge depends primarily on soil texture, vegetation, and climate (Gee et al. 1992; PNL-10285). Natural recharge rates range from near zero, where fine-grained soil and deep-rooted vegetation are present, to greater than 10 centimeters per year (4 inches per year) in areas where soil is coarse textured and bare of vegetation.

Large-scale, artificial recharge to the unconfined aquifer occurred because of past liquid waste disposal in the operating areas and offsite agricultural irrigation to the west and south. Discharge of wastewater caused the water table to rise over most of the Hanford Site. Since the peak discharge in 1984, discharge of wastewater to the ground has been significantly reduced and, in response, the water table subsequently declined over most of the site. The water table continues to decline, as illustrated by Figure 7.1.7. The water table declined up to 0.5 meter (1.6 feet) over most of the site between 1999 and 2000. The largest decline in the water table was 0.75 meter (2.5 feet) near a pump-and-treat system in the 200-West Area.

The decline in the water table has altered the flow pattern of the unconfined aquifer, which is generally from the recharge areas in the west to the discharge areas (primarily the Columbia River) in the east and north. Water levels in the unconfined aquifer have continually changed as a result of variations in the volume and location of wastewater discharge. Consequently, the movement of groundwater and its associated constituents has also changed with time (see Section 7.1.6).

In the past, two major groundwater mounds formed near the 200-East and 200-West Areas in response to wastewater discharges. The first of these mounds was created by disposal at the 216-U-10 pond (U Pond) in the 200-West Area. After U Pond
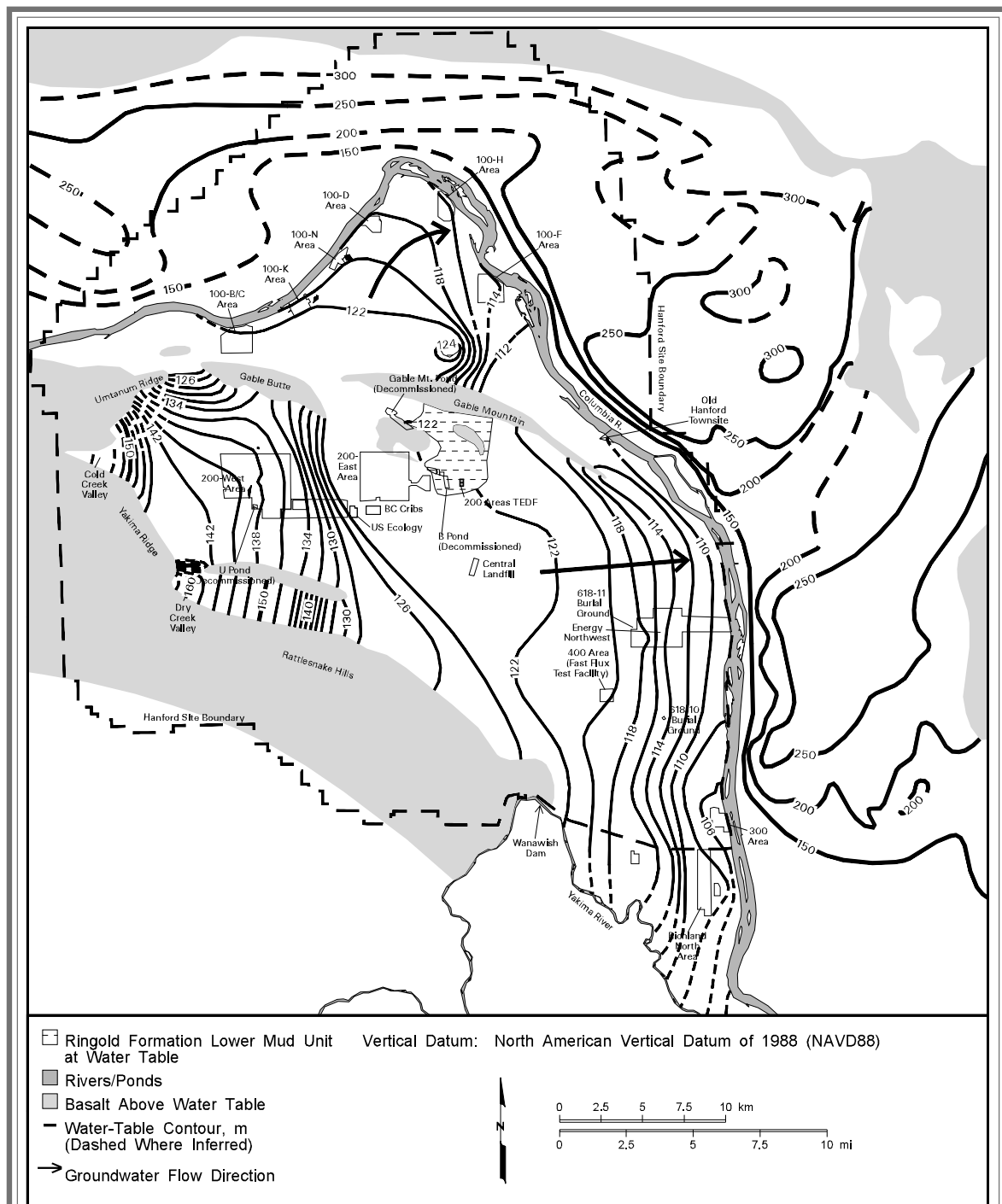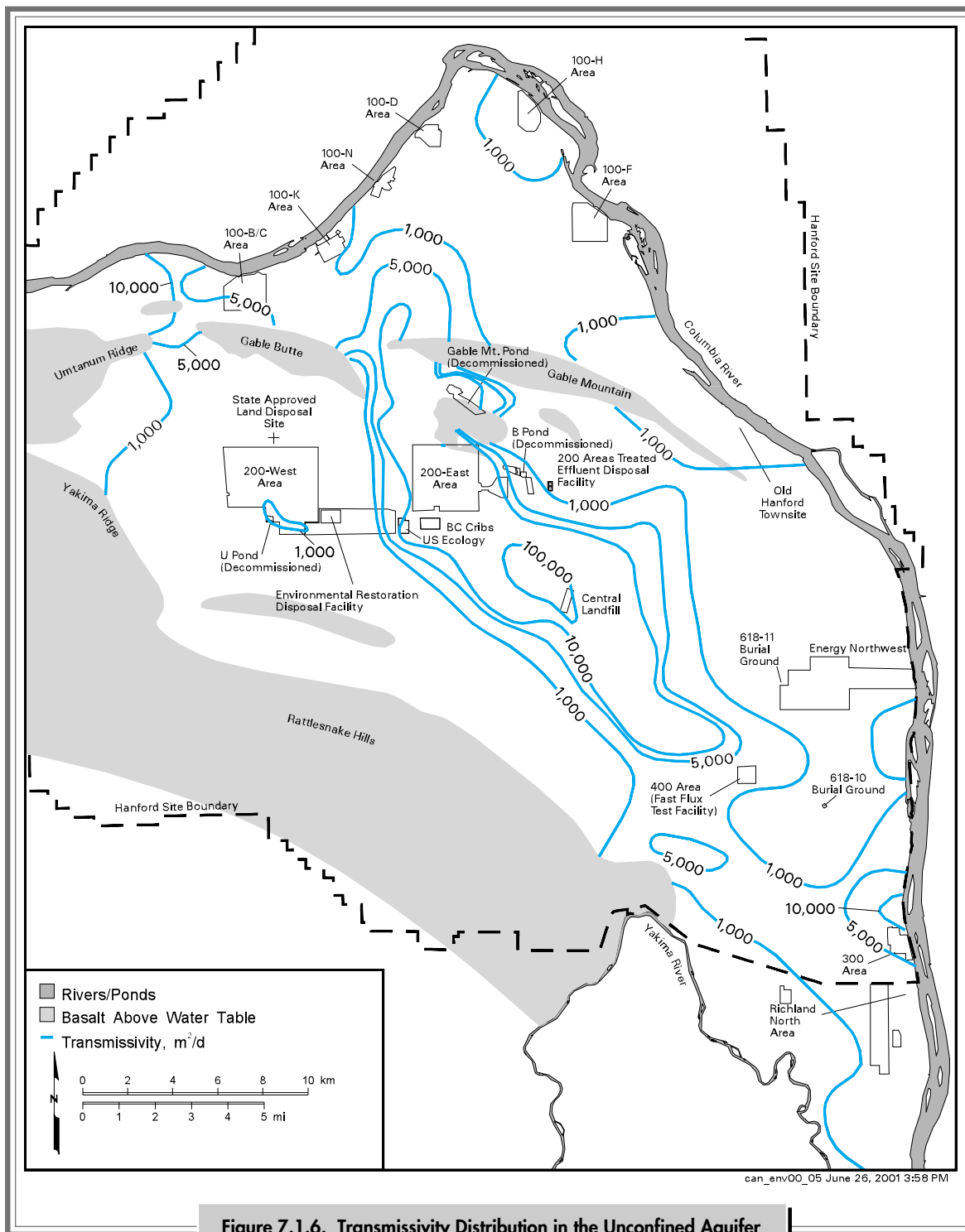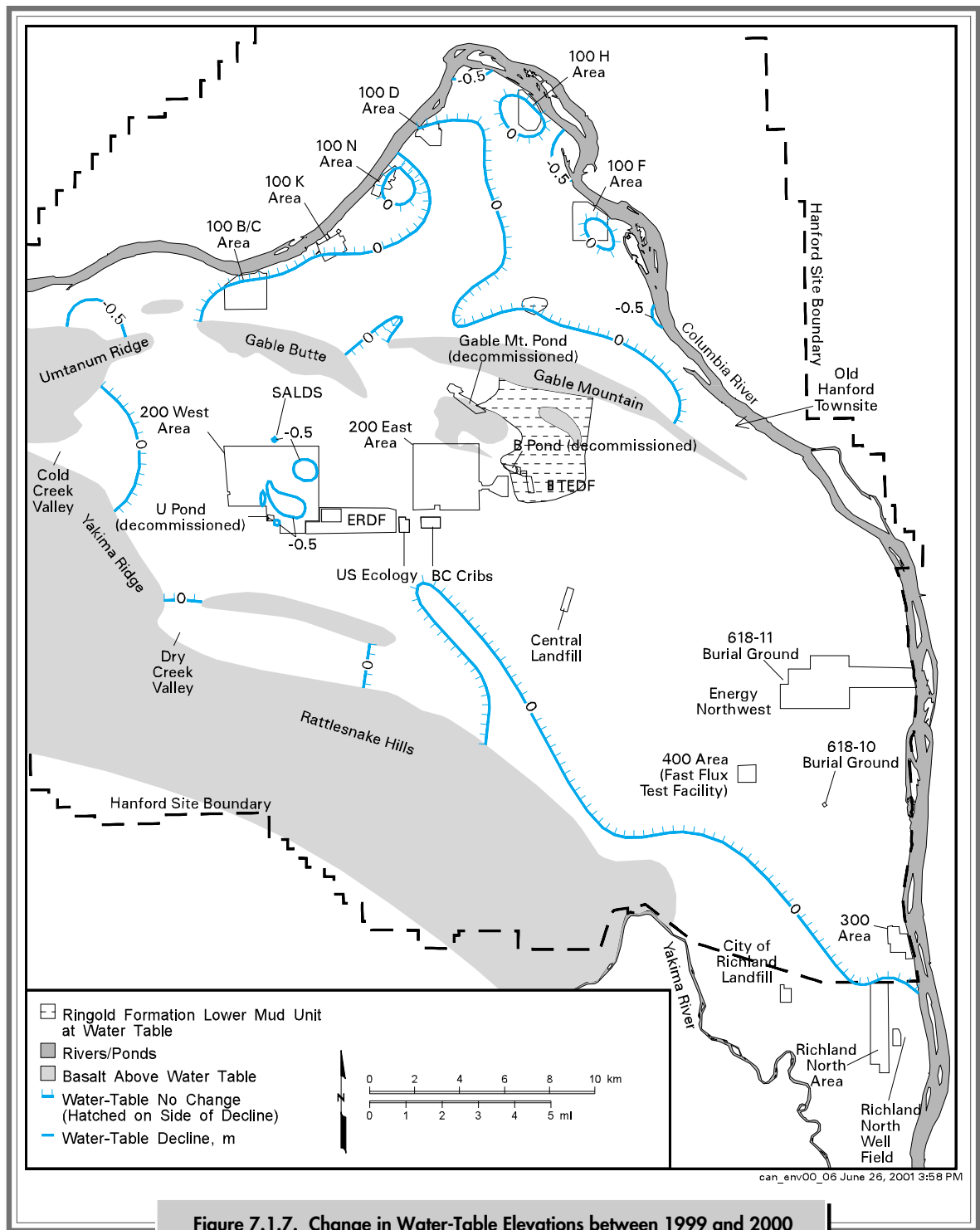
Figure 7.1.5. Water-Table Elevations for the Unconfined Aquifer at the Hanford Site and in Adjacent Areas East and North of the Columbia River, March/April 2000

Figure 7.1.6. Transmissivity Distribution in the Unconfined Aquifer

Figure 7.1.7. Change in Water-Table Elevations between 1999 and 2000

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was decommissioned in 1984, the mound slowly dissipated. The water table continues to decline in this area (see Figure 7.1.7). The second major mound was created by discharge to the decommissioned, or former, 216-B-3 pond (B Pond), east of the 200-East Area. The water-table elevation near B Pond increased to a maximum before 1990 and decreased because of reduced discharge. After discharge to B Pond ceased in August 1997, the decline in the water-table elevation accelerated. Groundwater mounding related to wastewater discharges also occurred in the 100 and 300 Areas in the past. However, groundwater mounding in these areas was not as great as in the 200 Areas primarily because of lower discharge volumes.

7.1.2.2 Hydrogeologic Studies

In 2000, the hydrogeology of the suprabasalt aquifer system in the 200-East Area and vicinity was re-evaluated (PNNL-12261). The purpose of the study was to refine the conceptual model of groundwater flow in the 200-East Area and vicinity. In this study, the suprabasalt sediment was separated into two aquifer systems, the Hanford unconfined aquifer and the confined Ringold aquifer system. These aquifer systems in this area previously had been referred to as either a basalt-confined aquifer system or a single suprabasalt aquifer.

Hydrostratigraphic mapping indicated that an aquiclude separating the aquifer systems is the most significant basin-wide confining unit within the suprabasalt sediment. This confining unit is composed of silts and clays of the Ringold Formation. The study also concluded that one or more buried ancient channels eroded into the Ringold Formation in a northwest to southeast direction across the 200-East Area. Groundwater and contaminants preferentially flow along this erosional channel.

7.1.3 Contaminant Transport

The history of contaminant releases and the physical and chemical principles of mass transport control the distribution of radionuclides and chemicals in groundwater. Processes that control the movement of these contaminants at the Hanford Site are discussed in the following paragraphs.

Most of the groundwater contamination at the Hanford Site resulted from discharge of wastewater from reactor operations, reactor fuel fabrication, and processing of spent reactor fuel. Table 7.1.1 lists the principal contaminants found in each operational area and the type of operation that generated them. In the 100 Areas, discharges included reactor cooling water, fuel storage basin water, filter backwash, and smaller amounts of waste from a variety of other processes. In the 200 Areas, large quantities of wastewater from fuel reprocessing were discharged

Table 7.1.1. Chemical and Radiological Groundwater Contaminants and Their Link to Site Operations		
Areas	**Facilities Type**	**Contaminants Generated**
100	Reactor operations	Tritium, ^{60}Co, ^{90}Sr, Cr^6, SO_4^{-2}
200	Irradiated fuel processing	Tritium, ^{90}Sr, ^{99}Tc, ^{129}I, ^{137}Cs, Pu, U, CN^-, Cr^6, F^-, NO_3^-
200	Plutonium purification	Pu, carbon tetrachloride, chloroform, NO_3^-
300	Fuel fabrication	^{99}Tc, U, Cr^6, trichloroethlene

to the ground. Other contamination sources in the 200 Areas included plutonium purification waste and decontamination waste. The plutonium purification process resulted in the discharge of large amounts of liquid organic chemicals in addition to aqueous solutions. This organic liquid, once in contact with groundwater, slowly dissolves and produces contaminant plumes. The presence of non-aqueous liquid has a major impact on the site's groundwater remediation strategy because the organic liquid in the subsurface represents a continuing source of contamination that is very difficult to clean up. Groundwater contamination in the 300 Area resulted mainly from discharge of waste from fuel fabrication.

Liquid effluents discharged to the ground at Hanford Site facilities percolated down through the unsaturated zone toward the water table. Radionuclide and chemical constituents move through the soil column and, in some cases, enter the groundwater. In some locations, sufficient water was discharged to saturate the soil column to the surface. Not all contaminants move at the same rate as the water in the subsurface. Chemical processes such as adsorption onto soil particles, chemical precipitation, and ion exchange slow the movement of some constituents such as strontium-90, cesium-137, and plutonium-239/240. However, these processes may be affected by the chemical characteristics of the waste such as high ionic strength, acidity, or presence of chemical complexants. Other radionuclides, such as technetium-99, iodine-129, and tritium, and chemicals, such as nitrate, are not as readily retained by the soil and move vertically through the soil column at a rate nearly equal to the infiltrating water. When the contaminants reach the water table, their concentrations are reduced by dilution with groundwater. As these dissolved constituents move with the groundwater, many radionuclides and chemicals adhere to sediment particle surfaces (adsorption) or diffuse into the particles (absorption). Radionuclide concentrations are also reduced by radioactive decay.

Outside the source areas (i.e., liquid disposal sites), there is typically little or no downward gradient (driving force or head), so contamination tends to remain in the upper part of the aquifer. In the source areas, where large volumes of wastewater were discharged, a large vertical hydraulic gradient developed that moved contaminants downward in the aquifer. Layers of low-permeability silt and clay within the unconfined aquifer also limit the vertical movement of contaminants. Flow in the unconfined aquifer is generally toward the Columbia River, which acts as a drainage area for the groundwater flow system at Hanford (see Figure 7.1.5). Contamination that reaches the river is further diluted by river water.

7.1.4 Groundwater Modeling

Researchers use numerical modeling of groundwater flow and contaminant transport to simulate future groundwater flow conditions and predict the migration of contaminants through the groundwater pathway. DOE consolidated multiple versions of sitewide groundwater flow and contaminant transport models into one model to eliminate redundancies and promote consistency in addressing sitewide groundwater problems (DOE/RL-2000-11). During 2000, the technical basis for predicting groundwater flow and contaminant transport was improved by 1) identifying and quantifying uncertainties in the model and 2) performing a transient calibration of the sitewide model. Three applications of the consolidated groundwater model were also performed in 2000. The code used for implementing the consolidated groundwater model is the Coupled Fluid, Energy, and Solute Transport (CFEST-96) code, which was developed by CFEST Co., Irvine, California (Gupta 1997).

In 2000, uncertainties in components of the model were identified. The components of the

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model having uncertainties included interaction between the unconfined aquifer and the upper basalt-confined aquifer, variability in recharge from surface runoff, variable flow of the Columbia and Yakima Rivers, irrigation effects on land adjacent to the Hanford Site, definition of boundary conditions, identification of hydrogeologic units, and hydraulic properties. Various conceptual models were developed and run, and the results were compared to quantify the sources of uncertainty.

A transient calibration of the sitewide groundwater model was performed in 2000 to improve the ability of the sitewide model to simulate historical changes in the water table elevation over the entire Hanford Site (PNNL-13447). Information on the rise and fall of the water table since 1943 was used to determine the distribution of aquifer hydraulic properties that produces the best match to the observed changes in the water-table elevation.

The consolidated groundwater model was used for three specific applications in 2000. One of the applications was to simulate the migration of carbon tetrachloride from the Z crib in the 200-West Area to an assumed compliance boundary ~5,000 meters (16,400 feet) from the source. The purpose of the study was to provide upper and lower estimates of the amount of carbon tetrachloride at the source area that will most likely result in carbon tetrachloride concentrations exceeding 5 µg/L at the boundary. The modeling was performed using assumed amounts of 487,500 kilograms (1.1 million pounds), 225,000 kilograms (496,000 pounds), 75,000 kilograms (165,000 pounds), and 7,500 kilograms (16,500 pounds) of carbon tetrachloride that reached groundwater. The modeling study concluded that between 7,500 kilograms (16,500 pounds) and 75,000 kilograms (165,000 pounds) of carbon tetrachloride would result in concentrations of 5 µg/L or more at the compliance boundary. If 75,000 kilograms (165,000 pounds) or more carbon tetrachloride reaches groundwater, then 5 µg/L would be exceeded at the boundary. Carbon tetrachloride concentrations would not likely exceed

5 µg/L at the boundary if 7,500 kilograms (16,500 pounds) or less carbon tetrachloride reached groundwater at the source area.

Groundwater flow and transport modeling was conducted to assess the performance of the Immobilized Low-Activity Waste Disposal Facility in the southern 200-East Area. The sitewide groundwater model simulated the transport of hypothetical contaminants, which are released to groundwater, from the facility to the Columbia River and to a hypothetical well 100 meters (330 feet) downgradient of the facility. The model results indicated that groundwater at the facility moves in a southeasterly direction and then in an easterly direction before reaching the Columbia River. The distance along this groundwater flow path is ~15 kilometers (9.3 miles). Assuming an infiltration rate of 4.2 mm/yr (0.2 inch/yr), an input concentration of $1\ Ci/m^3$ at the source release area would yield a maximum concentration of $0.0011\ Ci/m^3$ at a well 100 meters (330 feet) downgradient of the site. Greater levels of infiltration would result in lower concentrations of contaminants in the downgradient well.

The consolidated sitewide groundwater model was used as the groundwater component of the System Assessment Capability to simulate contaminant transport through the groundwater. The System Assessment Capability is a tool being developed to predict the cumulative sitewide effects from all significant contaminants at the Hanford Site. During 2000, historical data were compiled for the initial simulations of the groundwater model.

Groundwater models were used to continue assessing and improving the performance of groundwater pump-and-treat systems in operable units in the 100-K, 100-N, 100-D, 100-H, and 200-West Areas. The operable units and their associated contaminants of concern are presented in Table 7.1.2. In these pump-and-treat systems,

Table 7.1.2. Operable Units and Associated Contaminants of Concern

Area	Operable Unit	Contaminants of Concern
100-K	100-KR-4	Hexavalent chromium
100-N	100-NR-2	Strontium-90
100-H and 100-D	100-HR-3	Hexavalent chromium
200-West	200-UP-1	Technetium-99 and uranium
200-West	200-ZP-1	Carbon tetrachloride

contaminated water is removed by means of extraction wells, treated, and either disposed of to the State-Approved Land Disposal Site or returned upgradient to the aquifer through injection wells. The models were used to predict system performance and progress toward remediation goals. The modeling was used to evaluate different extraction and injection well configurations, predict effects of pumping, assess the extent of hydraulic influence and the capture zone, and evaluate groundwater travel times. Modeling was conducted using the Micro-FEM© finite-element code developed by C. J. Hemker, Amsterdam, The Netherlands.

Computer modeling was used to evaluate hydraulic capture and optimize the pumping rates of the pump-and-treat systems in the operable units in the 100-K, 100-N, 100-D, and 100-H Areas. The modeling results showed that the extraction wells were reducing the net groundwater flow to the Columbia River through the targeted plume area by ~76% in the 100-KR-4 Operable Unit (DOE/RL-2000-01). The modeling results also showed that, by optimizing the pumping rates and adding one extraction well, capture of the targeted plume area can be increased to ~84%. At the 100-NR-2 Operable Unit, the pump-and-treat system continued to reduce the net groundwater flow to the Columbia River by ~96% (DOE/RL-99-79). At the 100-D Area, which is part of the 100-HR-3 Operable unit, the model results indicated that groundwater passing through over 90% of the targeted plume area was

being intercepted by the extraction wells. At the 100-H Area, the other part of the 100-HR-3 Operable Unit, the extraction wells were capturing groundwater flowing through ~86% of the targeted plume area (DOE/RL-2000-01). The modeling predicted that the targeted plume area could be increased to ~98% when an additional extraction well is added to the pump-and-treat system. This extraction well began operating in 2000.

For the 200-UP-1 Operable Unit in the 200-West Area, modeling was performed to continue to evaluate the effectiveness in containing the targeted area of the technetium-99 and uranium plumes and track the progress of remediation. The modeling showed that one extraction well (299-W19-39) captured and contained the targeted area of high technetium-99 and uranium concentrations (DOE/RL-99-79). Since pump-and-treat systems started, the extraction well removed at least one pore volume of water from the targeted plume area by the end of September 2000. One pore volume is the total volume of pores considered collectively within the soil of the targeted plume. The ratio of the volume of water removed from the targeted area of the plume to the total volume of water removed from the aquifer, known as plume capture efficiency, was ~55% during 2000.

For the 200-ZP-1 Operable Unit in the 200-West Area, modeling was performed to evaluate the remedial action of the pump-and-treat system.

The modeling results indicated that the pump-and-treat extraction wells continue to contain the high carbon tetrachloride concentration area (greater than 4,000 µg/L) of the plume (DOE/RL-99-79). The modeling predictions showed that since pump-and-treat operations began, pumping had removed one pore volume of water from the upper 15 meters (49 feet) of the aquifer from an area of ~163,400 m^2 (195,400 ft^2) near the northernmost extraction wells. For the southernmost extraction wells, the modeling results showed that since pump-and-treat operations began, pumping had removed one pore volume from an area of ~80,300 m^2 (96,000 ft^2) around those wells. One pore volume is defined as the estimated total volume of pore space within a given area and thickness of aquifer.

7.1.5 Groundwater Monitoring

Groundwater monitoring at the Hanford Site is an integral part of the *Hanford Site Ground-Water Protection Management Plan* (DOE/RL-89-12). That plan assures that monitoring at active waste disposal facilities complies with requirements of RCRA and Washington State regulations, as well as requirements for operational monitoring around reactor and chemical processing facilities and environmental surveillance monitoring. Pacific Northwest National Laboratory manages these monitoring efforts to assess the distribution and movement of existing groundwater contamination, to identify and characterize potential and emerging groundwater contamination problems, and to integrate the various groundwater projects to minimize redundancy.
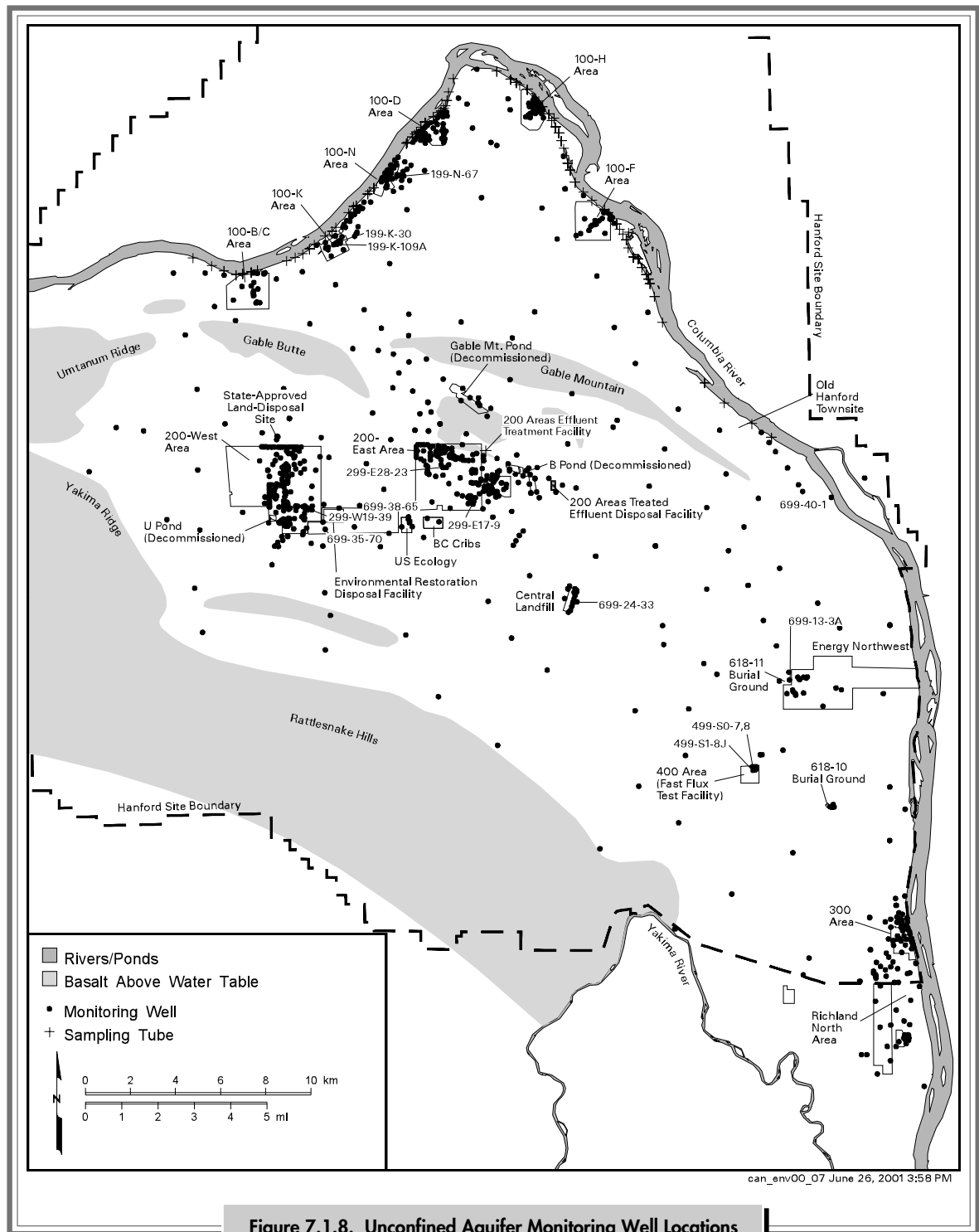
The *Integrated Monitoring Plan for the Hanford Groundwater Monitoring Project* (PNNL-11989) describes how the DOE will implement the groundwater monitoring requirements outlined in DOE (1987) and DOE/RL-89-12. The purpose of the integrated monitoring plan is to 1) describe the monitoring well networks, constituents, sampling frequencies, and criteria used to design the monitoring program; 2) identify federal and state groundwater monitoring requirements and regulations; and 3) provide a list of wells, constituents, and sampling frequencies for groundwater monitoring conducted on the Hanford Site. Federal and state regulations include RCRA, CERCLA, and Washington Administrative Codes (see Section 2.2).
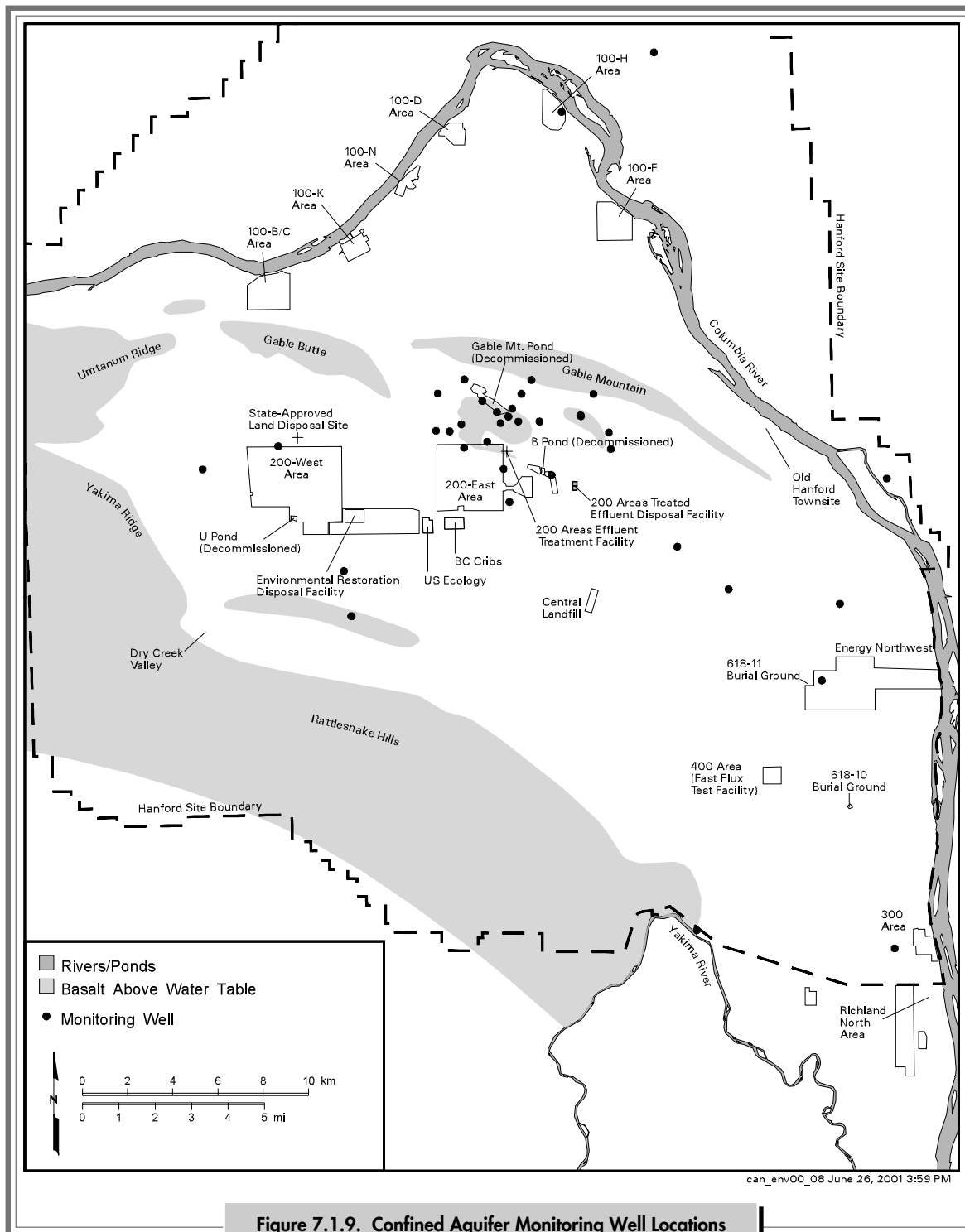
Information on contaminant distribution and transport are integrated into a sitewide evaluation of groundwater quality, which is documented in an annual groundwater monitoring report (e.g., PNNL-13404). Groundwater monitoring is also carried out during CERCLA cleanup investigations. These investigations, managed by Bechtel Hanford, Inc., are documented in annual summary reports (e.g., DOE/RL-2000-01).

7.1.5.1 Groundwater Sampling and Analytes of Interest

Groundwater samples were collected from 694 wells for all monitoring programs during 2000. The locations of sampled wells are shown in Figures 7.1.8 and 7.1.9; well names are indicated only for those wells specifically discussed in the text. Because of the density of unconfined aquifer wells in the operational areas, well names in these areas are also shown on detailed maps in the following sections. Figure 7.1.10 shows the locations of facilities where groundwater monitoring was conducted to comply with RCRA (also see Appendix A in PNNL-13404). Wells at the Hanford Site generally follow a naming system that indicates the approximate location of the well. The prefix of the well name indicates the area of the site, as shown in Table 7.1.3. The names for 600 Area wells follow a local coordinate system in which the numbers

Figure 7.1.8. Unconfined Aquifer Monitoring Well Locations

7.20

Figure 7.1.9. Confined Aquifer Monitoring Well Locations

Map labels:

100-H Area
100-D Area
100-N Area
100-F Area
100-K Area
100-B/C Area

Hanford Site Boundary

Columbia River

Umtanum Ridge
Gable Butte
Gable Mt. Pond (Decommissioned)
Gable Mountain

State-Approved Land Disposal Site

200-West Area
B Pond (Decommissioned)

Old Hanford Townsite

Yakima Ridge

U Pond (Decommissioned)
200-East Area
200 Areas Treated Effluent Disposal Facility

Environmental Restoration Disposal Facility
US Ecology
BC Cribs
200 Areas Effluent Treatment Facility

Central Landfill

Dry Creek Valley

Energy Northwest
618-11 Burial Ground

Rattlesnake Hills

400 Area (Fast Flux Test Facility)
618-10 Burial Ground

Hanford Site Boundary

300 Area

Yakima River

Richland North Area

Legend:
Rivers/Ponds
Basalt Above Water Table
• Monitoring Well

0 2 4 6 8 10 km
0 1 2 3 4 5 mi

N

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Figure 7.1.10. Locations of RCRA Groundwater Monitoring Projects

The figure shows locations of various monitoring areas including 100-N Area, 100-H Area, 200-West Area, 200-East Area, Central Landfill Area, and 300 Area along the Columbia River.

Labels in figure:
- 100-N Area: 1301-N LWDF, 1325-N LWDF, 1324-N/NA Pond
- 100-H Area: 183-H Solar Evaporation Basins
- 200-West Area: LLWMA 3, WMA-T SST, WMA-TX-TY SST, LLWMA 4, WMA-U SST, WMA-S-SX SST, 216-U-12 Crib, 216-S-10 Pond and Ditch
- Central Landfill Area: NRDWL, SWL
- 200-East Area: WMA-B-BX-BY SST, LLWMA 2, LLWMA 1, LERF, 216-B-63 Trench, WMA-C SST, WMA-A-AX SST, PUREX, (3) (3A) 216-B-3 Pond (B Pond), (3B), (3C), 216-A-29 Ditch, 216-A-37-1 Crib, 216-A-36B Crib, 216-A-10 Crib, PUREX Cribs(a)
- 300 Area: Process Trenches
- Columbia River
- Not to Scale

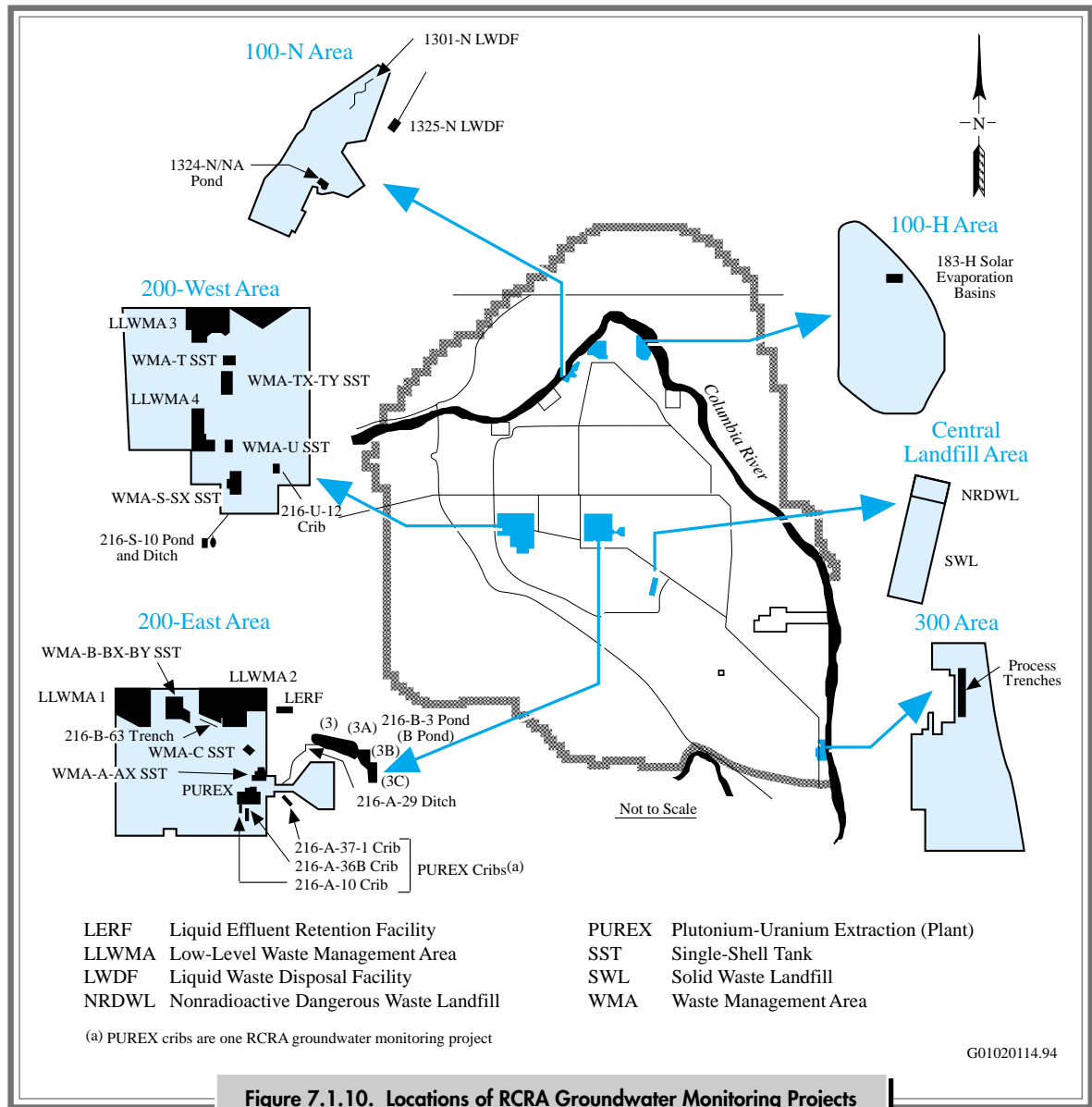| Abbreviation	Definition
LERF	Liquid Effluent Retention Facility
LLWMA	Low-Level Waste Management Area
LWDF	Liquid Waste Disposal Facility
NRDWL	Nonradioactive Dangerous Waste Landfill
PUREX	Plutonium-Uranium Extraction (Plant)
SST	Single-Shell Tank
SWL	Solid Waste Landfill
WMA	Waste Management Area

(a) PUREX cribs are one RCRA groundwater monitoring project

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indicate the distance relative to an arbitrary datum location in the south-central part of the site.

The monitoring frequency for the wells was selected by Pacific Northwest National Laboratory based on regulatory requirements, variability of historical data, proximity to waste sources (PNL-6456), and characteristics of the groundwater flow system at the sample location. Of the 694 wells sampled, 295 were sampled once, 145 twice, 88 three times, 101 four times, and 65 wells were sampled more than four times during the year. The sampling frequency is every 3 years for several wells that have consistently shown concentrations with steady historical trends. Wells showing larger variability are sampled more frequently (annually or more often). Wells that monitor source areas are sampled more frequently than wells that do not monitor source areas. Contaminants with greater mobility (e.g., tritium) in groundwater may be sampled more frequently than contaminants that are not very mobile (e.g., strontium-90). The sampling

| Table 7.1.3. Hanford Site Well Naming System |||

Example Well Name	Area
199-	**100 Areas**
199-B3-47	100-B/C Area
199-D5-12	100-D Area
199-F8-3	100-F Area
199-H4-3	100-H Area
199-K-30	100-K Area
199-N-67	100-N Area
299-	**200 Areas**
299-W19-3	200-West Area
299-E28-4	200-East Area
399-	**300 Area**
399-1-17A	300 Area
499-	**400 Area**
499-S1-8J	400 Area
699-	**600 Area**
699-50-53A	600 Area north and west of datum
699-42-E9A	600 Area north and east of datum
699-S19-11	600 Area south and west of datum
699-S19-E13	600 Area south and east of datum

Note: Letters at end of well names distinguish either multiple wells located close together or multiple intervals within a single well bore.

Most groundwater monitoring wells on the site are 10 to 20 centimeters (4 to 8 inches) in diameter. Monitoring wells for the unconfined aquifer are constructed with well screens or perforated casing generally in the upper 3 to 6 meters (10 to 20 feet) of the unconfined aquifer, with the open interval extending across the water table. This construction allows sample collection at the top of the aquifer, where maximum concentrations of radionuclides and maximum concentrations of chemicals tend to be found. Wells monitoring the shallowest of the basalt-confined aquifers have screens, perforated casing, or an open hole within the monitored aquifer. Wells drilled before 1985 were generally constructed with carbon steel casing. Since 1985, RCRA monitoring wells and CERCLA characterization wells have been constructed with stainless steel casing and screens. Most monitoring wells on the site are sampled using either submersible or Hydrostar™ pumps (a registered trademark of Instrumentation Northwest, Inc., Redmond, Washington), though some wells are sampled with bailers or airlift systems.

Samples were collected for all programs following documented sampling procedures (PNL-6894; ES-SSPM-001) based on U.S. Environmental Protection Agency (EPA) guidelines (OSWER 9950-1). Analytical techniques used are listed in PNNL-13080 and CERCLA work plans. The samples were analyzed for the radionuclides and chemicals listed in Table 7.1.4.

Most groundwater samples collected on the site in 2000 were analyzed for tritium. Selected samples were analyzed for other radionuclides. Sample results for radionuclides are generally presented in picocuries per liter; however, the results for total uranium, which is usually measured by laser fluorescence, are given in micrograms per liter.

Nitrate analyses were performed on many samples collected during 2000 because of the extensive areas with elevated nitrate concentrations that

of some wells in 2000 was delayed or cancelled due to issues associated with disposal of secondary sampling waste, such as gloves. An acceptable practice for disposing of the waste was implemented during 2000.

Each monitoring program has access to groundwater data collected by other programs through a common database, the Hanford Environmental Information System. This database contains more than 1.6 million groundwater monitoring result records. After the data are verified and/or validated, they are made available to federal and state regulators for retrieval.

originate from onsite and offsite sources (see Section 7.1.6.2). However, nitrate concentrations were below the EPA 45-mg/L drinking water standard (40 CFR 141) for most of the affected area. Selected monitoring wells were used for additional chemical surveillance.

7.1.5.2 Data Interpretation

Each analysis of a groundwater sample provides information on the composition of groundwater at one time at one location in the aquifer. Uncertainty in the analyses results from a number of sources. Some of the sources of uncertainty are discussed below. Several techniques used to interpret the sample results also are discussed.

Groundwater sampling techniques are designed to collect a sample that is representative of the constituent concentration in the aquifer when the sample is taken. However, there are limitations in collecting representative samples or even defining precisely the volume of the aquifer represented by the sample. Proper well construction and maintenance, well purging, sample preservation, and, in some instances, filtering are used to help ensure consistent and representative samples. Careful sample labeling protocols, chain-of-custody documentation, and bottle preparation avoid many gross errors in sample results. Duplicate samples and field blanks are used to assess the sampling procedure.

Table 7.1.4. Groundwater Analyzed for Radionuclides and Chemicals in 2000	
Radiological Parameters	**Chemical and Biological Parameters**
Tritium	pH (field)
Beryllium-7	Conductance (field and laboratory)
Carbon-14	Total dissolved solids
Potassium-40	Alkalinity
Cobalt-58	Total organic carbon
Iron-59	Total organic halogens
Cobalt-60	Be, Na, Mg, Al, K, Co, Si, As, Se, P
Strontium-90	Ca, V, Cr, Mn, Fe, Ni, Pb, Li, Hg
Technetium-99	Cu, Zn, Sr, Ag, Cd, Sb, Ba, Sn, Tl, Ti
Ruthenium-106	F^-, Cl^-, NO_3^-, PO_4^{-3}, SO_4^{-2}, NO_2^-, Br^-
Antimony-125	CN^-
Iodine-129	NH_4^+
Cesium-134	Hexavalent chromium
Cesium-137	Volatile organic compounds
Neptunium-237	Semivolatile organic compounds
Americium-241	Polychlorinated biphenyls
Gross alpha	Pesticides
Gross beta	Biochemical oxygen demand
Europium isotopes	Chemical oxygen demand
Plutonium isotopes	Coliform bacteria
Radium isotopes	Dissolved oxygen (field)
Uranium isotopes	Total petroleum hydrocarbons
Uranium (total)	Oil and grease
Barium-133	Gasoline
Thorium isotopes	Hardness
Total beta radiostrontium	Oxidation reduction potential
Nickel-63	Temperature
	Turbidity
	Boron
	Molybdenum
	Silica

Uncertainties are inherent in laboratory analyses of samples. Gross errors can be introduced in the laboratory or during sampling. Gross errors include transcription errors, calculation errors, mislabeling, field equipment problems, or other errors that result from not following established procedures. Often, these gross errors can be recognized because unreasonably high or unreasonably low values result. Data review protocols are used to investigate and correct gross errors.

Random errors are unavoidably introduced in the analytical procedures. Usually, there are insufficient replicate analyses to assess the overall random error at each sample location. Instruments to analyze for radioactive constituents count the number of radioactive decay products at a detector, and background counts are subtracted. The nature of radioactive decay and the instrument design result in a random counting error that is reported with the analytical result. Generally, a sample result less than the counting error indicates the constituent was not detected. The background subtraction may result in the reporting of results that are less than zero. Although below-zero results are physically impossible, the negative values are of use for some statistical analyses (see Appendix A for more details).

Systematic errors may result from problems with instrument calibration, standard or sample preparation, chemical interferences in analytical techniques, as well as sampling methodology and sample handling. Sample and laboratory protocols have been designed to minimize systematic errors. The analytical laboratories participate in interlaboratory comparisons, in which many laboratories analyze blind samples prepared by the EPA (see Section 9.0).

In 2000, double-blind samples for specific constituents were analyzed (Section 9.0 discusses double-blind results). Several wells were also cosampled with the Washington State Department of Health for comparison, and the results are available from that agency.

The chemical composition of groundwater may fluctuate from differences in the contaminant source, recharge, or groundwater flow field. The range of this concentration fluctuation can be estimated by taking many samples, but there are limits to the number that can be practicably taken. Comparison of results through time helps interpret this variability.

Overall sample uncertainty may be factored into data evaluation by considering the concentration trend in a given well over time. This often helps identify gross errors, and overall, long-term trends can be distinguished from short-term variability. The interpretation of concentration trends depends on an understanding of chemical properties as well as site hydrogeology. The trend analysis, in turn, aids in refining the conceptual model of the chemical transport.

Plume maps presented in this section illustrate site groundwater chemistry. Although analytical data are available only at specific points where wells were sampled, contours are drawn to join the approximate locations of equal chemical concentration or radionuclide activity levels. The contour maps are simplified representations of plume geometry because of map scale, the lack of detailed information, and the fact that plume depth and thickness cannot be fully represented on a two-dimensional map. Plume maps are powerful tools because knowledge of concentrations in surrounding wells, groundwater flow, site geology, and other available information are factored into their preparation.

7.1.6 Groundwater Monitoring Results

The following sections summarize the distribution of radioactive and chemical contaminants detected in Hanford Site groundwater during 2000. These discussions are followed by a summary of groundwater monitoring results for RCRA sites. Detailed information on groundwater monitoring, including listings of analysis results for each monitoring well in electronic format, is available in PNNL-13404. However, because PNNL-13404 (the annual groundwater report) covers the fiscal year (October 1999 through September 2000), it does not include results from the last 3 months of 2000. This report includes results for January through December 2000.

One way to assess the impact of radionuclides and chemicals in groundwater is to compare them to EPA's drinking water standards and DOE's derived concentration guides (40 CFR 141 and DOE Order 5400.5; see Appendix D, Tables D.2 and D.5). The drinking water standards were established to protect public drinking water supplies. The derived concentration guides were established to protect the public from radionuclides resulting from DOE operations. Specific drinking water standards have been defined for only a few radiological constituents. Drinking water standards have been calculated for other radionuclides, using an annual dose of 4 mrem/yr. Calculations of these standards consider their half-life, the energy and nature of the radioactive decay, and the physiological factors such as its buildup in particular organs. Drinking water standards are more restrictive than derived concentration guides because the standards are based on an annual dose of 4 mrem/yr to the affected organ. The guides are based on an effective dose equivalent of 100 mrem/yr (see Appendix D, Tables D.2 and D.5). In addition, the standards use older factors for calculating the concentrations that would produce a 4-mrem/yr dose than are used in calculating the guides. Thus, the values used below for standards are not always in agreement with the guides, which are available only for radionuclides. Primary and secondary drinking water standards are given for some chemical constituents; secondary standards are based on aesthetic rather than health considerations.

The total area of contaminant plumes with concentrations exceeding drinking water standards was estimated to be ~231 square kilometers (89 square miles) in 2000. This area, which is a decrease of ~9% compared to 1999, occupies ~15% of the total area of the Hanford Site. Most of the contaminant plume area lies southeast of the 200-East Area extending to the Columbia River (Figure 7.1.11). The most widespread contaminants within these plumes were tritium, iodine-129, technetium-99, uranium, strontium-90, carbon tetrachloride, nitrate, and trichloroethene. Contaminant plumes with concentrations exceeding

derived concentration guides occur in isolated areas. The only contaminants at levels above the derived concentration guide in 2000 were tritium, uranium, and strontium-90.

7.1.6.1 Radiological Monitoring Results for the Unconfined Aquifer

Hanford Site groundwater was analyzed for the radionuclides listed in Table 7.1.4. The distribution of tritium, iodine-129, technetium-99, uranium, strontium-90, carbon-14, cesium-137, cobalt-60, and plutonium are discussed in the following sections. Tritium and iodine-129 are the most widespread radiological contaminants associated with past site operations. Technetium-99 and uranium plumes are extensive in the 200 Areas and adjacent 600 Area. Strontium-90 plumes exhibit very high concentrations in the 100 Areas but are of relatively smaller extent. Strontium-90 also occurs in the 200 Areas and near the former Gable Mountain Pond in the 600 Area. Carbon-14 is present in two small plumes in the 100-K Area. Cesium-137, cobalt-60, and plutonium contamination occurs in isolated areas in the 200 Areas. Gross alpha and gross beta are used as indicators of radionuclide distribution and are not discussed in detail because the specific radionuclides contributing to these measurements are discussed individually. Several other radionuclides, including ruthenium-106, antimony-125, and americium-241, are associated with waste from Hanford Site operations. Because of their very low activities in groundwater, they are not discussed in this section. Half-lives of the radionuclides are presented in Appendix A, Table A.5.

Tritium. Tritium, which is present in irradiated nuclear fuel, was released in process condensates associated with decladding and dissolution of the fuel. Tritium was also manufactured as part of the Hanford mission by irradiating targets containing lithium in several reactors from 1949 to 1952 (DOE/EIS-0119F; WHC-SD-EN-RPT-004). In the

7.26

Figure 7.1.11. Average Tritium Concentrations in the Unconfined Aquifer, 2000

Legend:
- Ringold Formation Lower Mud Unit at Water Table
- Rivers/Ponds
- Basalt Above Water Table
- Tritium, 20,000 pCi/L (DWS) 2,000,000 pCi/L (DCG) Dashed Where Inferred
- Monitoring Well
- Sampling Tube

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late 1960s, tritium production took place in N Reactor (WHC-MR-0388).

Tritium was present in many historical waste streams at the Hanford Site and is highly mobile, essentially moving at the same velocity as the groundwater. Consequently, the extent of groundwater contamination from site operations is generally reflected by tritium distribution. For this reason, tritium is the most frequently monitored radionuclide at the Hanford Site. Figure 7.1.11 shows the 2000 distribution of tritium in the unconfined aquifer. Tritium is one of the most widespread contaminants in groundwater across the Hanford Site and exceeded the 20,000-pCi/L drinking water standard in portions of the 100, 200, 400, and 600 Areas. Of these areas, tritium levels exceeded the 2 million-pCi/L derived concentration guide in portions of the 200 and 600 Areas. The highest tritium concentration measured at the Hanford Site in 2000 was 8.38 million pCi/L near the 618-11 burial ground. Tritium levels are expected to decrease because of dispersion and radioactive decay (half-life is 12.35 years).

In 2000, the only liquid effluent containing tritium was discharged to the soil column at the State-Approved Land Disposal Site, which began operating in 1995 and is located just north of the 200-West Area. The total radioactivity received by this facility in 2000 was ~21 curies, which was attributed solely to tritium.

Tritium in the 100 Areas. In 2000, there was no waste containing tritium discharged in the 100 Areas. All the tritium detected here comes from past activities at Hanford. Tritium concentrations greater than the drinking water standard were detected in portions of the 100-B/C, 100-F, 100-K, and 100-N Areas. The largest tritium plume in the 100 Areas with concentrations above the drinking water standard occurs along the Columbia River from the 100-N Area to an area southwest of the 100-D Area.

Tritium concentrations continued to exceed the drinking water standard in several wells in the northern and southwestern parts of the 100-B/C Area in 2000. Most of the tritium contamination is associated with past liquid disposal practices at 100-B/C retention basins and trenches near the Columbia River. The maximum tritium concentration decreased to 39,900 pCi/L in the northern part of the 100-B/C Area.

One well in the 100-F Area contained tritium at concentrations greater than the drinking water standard. A maximum of 24,400 pCi/L occurred near the 118-F-1 burial ground in 2000. This was a decrease from the 1999 maximum. The burial ground received only solid waste, and the source of the tritium contamination is not known.

A tritium plume near the KE Reactor in the 100-K Area continued to contain the highest tritium concentrations within the 100 Areas. The maximum concentration was 1.75 million pCi/L immediately downgradient of the 116-KE-1 crib (Figure 7.1.12). The tritium concentrations at this location (well 199-K-30) are most likely the result of downward migration of tritium in moisture from the vadose zone. This tritium is associated with the 116-KE-1 crib. The tritium trend for well 199-K-30 is shown in Figure 7.1.13. Tritium concentrations in the plume farther downgradient of the 116-KE-1 crib rose to levels above the drinking water standard in 2000. This rise in tritium concentrations may indicate the arrival of a tritium plume originating from leakage of the KE Fuel Storage Basin in 1993. Tritium levels greater than the drinking water standard, but much less than the derived concentration guide, continued to occur during 2000 in a small area near a pump-and-treat extraction well adjacent to the Columbia River.

Soil gas samples were collected from the overlying vadose zone north and east of the KE Reactor and analyzed for helium-3 to determine whether a tritium plume in groundwater could be detected (PNNL-13217). The analysis results indicated that
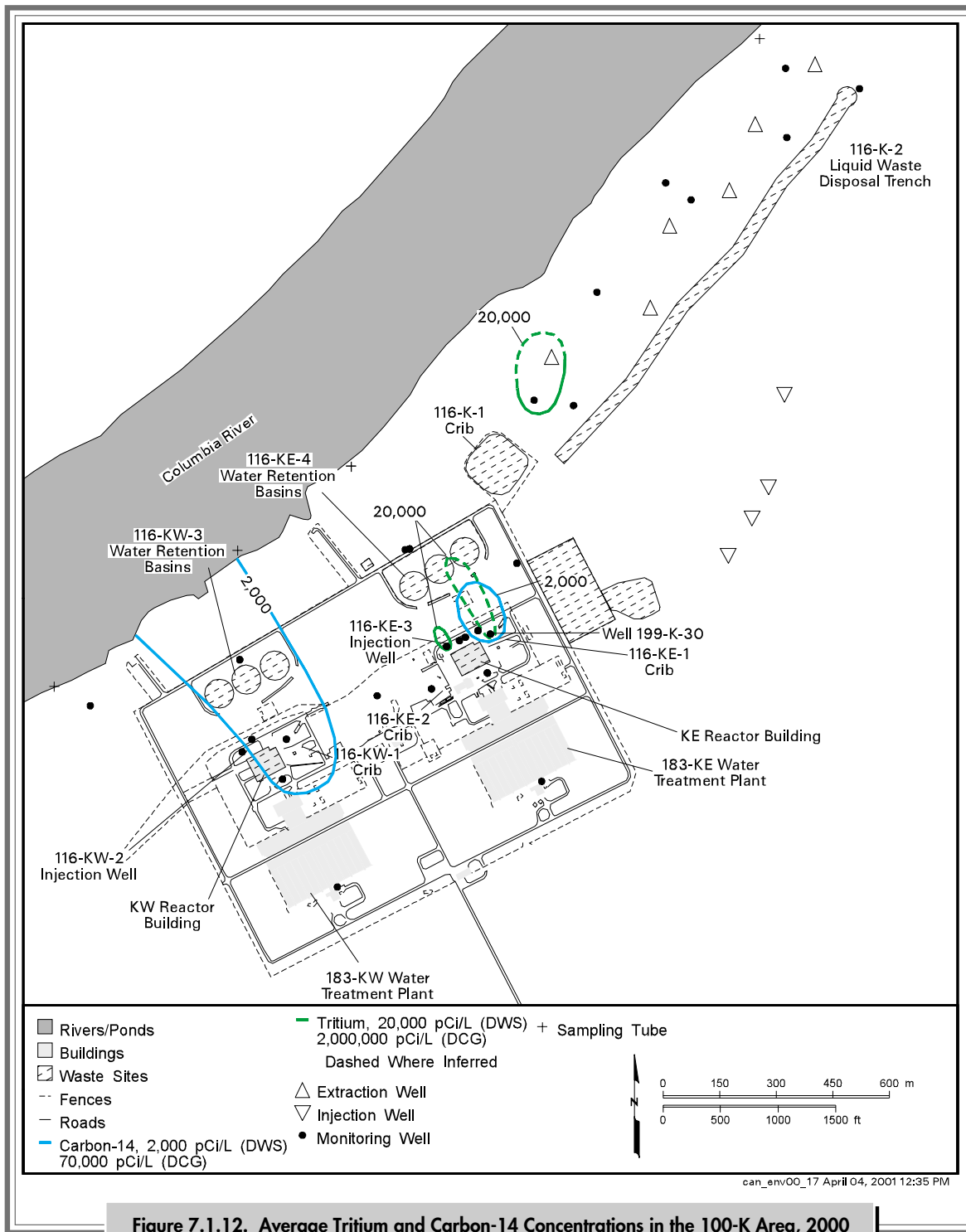
Figure 7.1.12. Average Tritium and Carbon-14 Concentrations in the 100-K Area, 2000
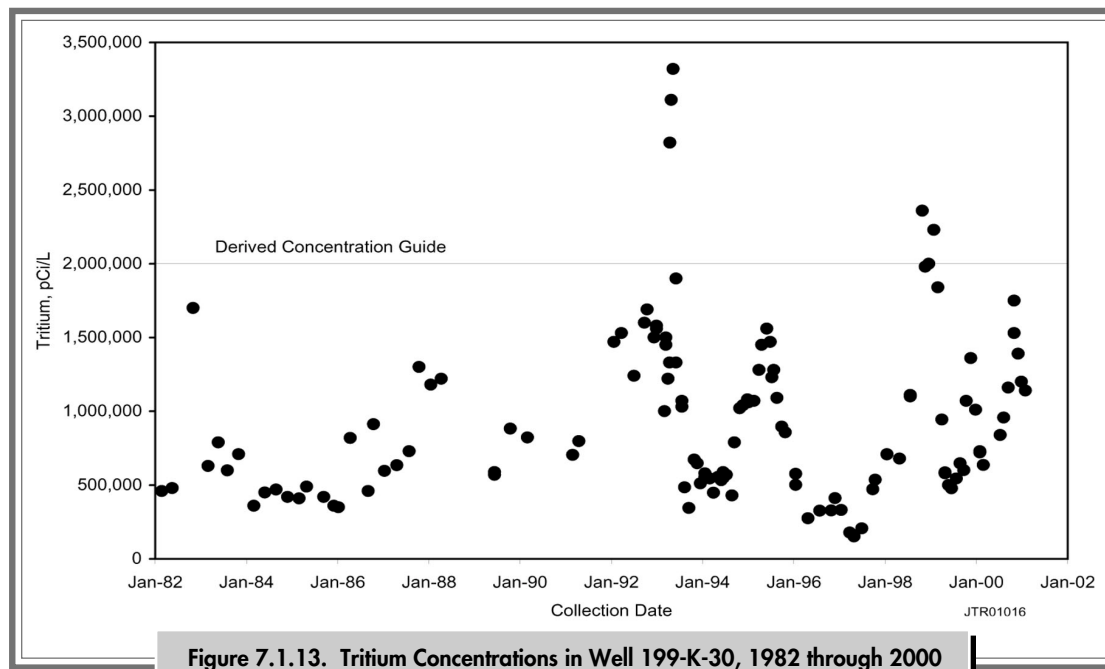
Hanford Groundwater Monitoring Project

Figure 7.1.13. Tritium Concentrations in Well 199-K-30, 1982 through 2000

a tritium plume could not be detected. Also, tritium was not detected in soil moisture samples collected from the same general area.

A tritium plume at levels exceeding the drinking water standard extends northeast from the northern part of the 100-N Area to the 600 Area along the Columbia River. This plume is associated with past liquid disposal to the 1301-N and 1325-N Liquid Waste Disposal Facilities. The size of the tritium plume continued to decrease in 2000 because of dispersion and radioactive decay. The maximum tritium level reported in the 100-N Area in 2000 was 45,000 pCi/L near the Columbia River.

Tritium in the 200-East and 600 Areas. The highest tritium concentrations in the 200-East Area continued to be measured in wells near cribs that received effluent from the Plutonium-Uranium Extraction Plant. Tritium levels are decreasing slowly in most wells in this area because of dispersion and radioactive decay. However, levels greater than the derived concentration guide detected in one well (299-E17-9) showed an increase in 2000. The maximum tritium level detected in this well was 4.1 million pCi/L in 2000, which is an increase from the

maximum of 2.45 million pCi/L in 1999. Well 299-E17-9 monitors the 216-A-36B crib in the southeastern part of the 200-East Area. Tritium concentrations continued to exceed the drinking water standard in many wells monitoring the cribs near the Plutonium-Uranium Extraction Plant.

In the plume that extends from the southeastern portion of the 200-East Area, tritium concentrations above 200,000 pCi/L occurred in a small area downgradient of the Plutonium-Uranium Extraction Plant and did not extend beyond the 200-East Area boundary. The plume area at levels above 200,000 pCi/L has extended at least as far southeast as the Central Landfill in the past (PNL-8073).

A widespread tritium plume extends from the southeastern portion of the 200-East Area to the Columbia River (see Figure 7.1.11). In the western portion of the tritium plume, a control in the movement of the plume to the southeast is the presence of the low permeability Ringold Formation lower mud unit at the water table east of the 200-East Area (PNNL-12261). Flow to the southeast also appears to be controlled by a zone of

7.30

highly permeable sediment, stretching from the 200-East Area toward the 400 Area (PNL-7144). Near Energy Northwest, an area of lower tritium concentration is a result of a higher degree of cemented sediment in the unconfined aquifer. The shape of the tritium plume indicates that tritium discharges to the Columbia River between the Old Hanford Townsite and the 300 Area.

Separate tritium pulses associated with the two episodes of Plutonium-Uranium Extraction Plant operations can be distinguished in the plume. A trend plot (Figure 7.1.14) of the tritium concentrations in well 699-40-1 east of the 200-East Area near the shore of the Columbia River clearly shows the arrival of a pulse in the mid-1970s. High tritium concentrations near the Columbia River result from discharges to the ground during the operation of the Plutonium-Uranium Extraction Plant from 1956 to 1972. Following an 11-year shutdown, plant operation began in 1983 and ceased in December 1988. This resulted in elevated tritium levels measured in several wells downgradient

from the 200-East Area. Movement of the leading edge of this later pulse shows arrival near the Central Landfill in early 1987 (Figure 7.1.15). Tritium concentrations from the earlier pulse were at least three times the maximum concentrations in the later pulse. The effects of the 1983 to 1988 operational period have not been detected near the Columbia River.

The tritium plume, which has been monitored since the 1960s, provides information on the extent of groundwater contamination over time. Figure 7.1.16 shows the distribution of tritium in selected years from 1964 through 2000. This figure was created from maps in BNWL-90, BNWL-1970, PNL-5041, PNL-6825 (Section 5.0), PNNL-11141, and PNNL-13404. The contours in the original references were recalculated and interpreted to provide uniform contour intervals. Figure 7.1.16 shows that tritium at levels greater than the drinking water standard reached the Columbia River near the Old Hanford Townsite in approximately the mid-1970s. By the late 1980s, tritium at these levels
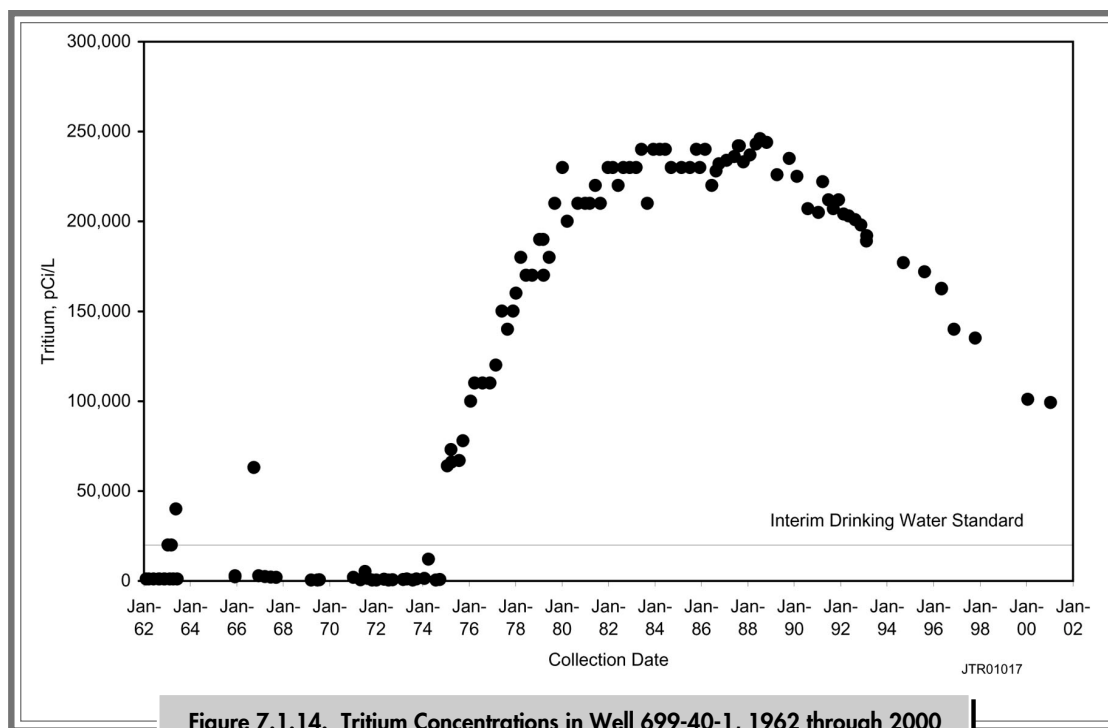

Figure 7.1.14. Tritium Concentrations in Well 699-40-1, 1962 through 2000
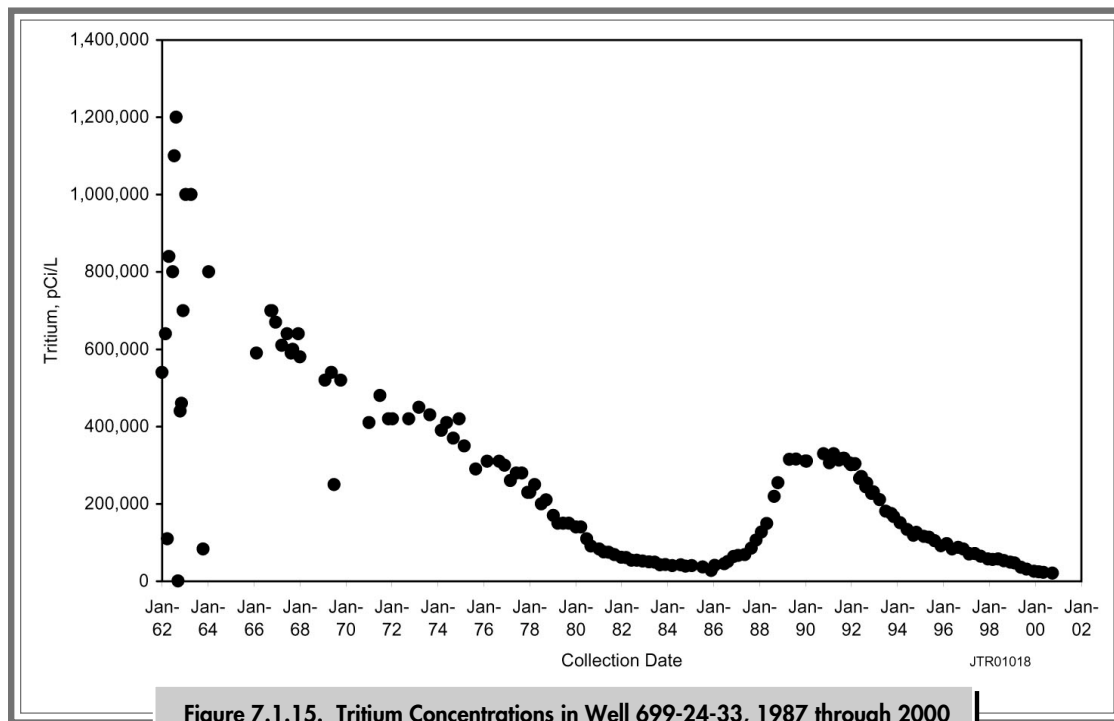
Hanford Groundwater Monitoring Project

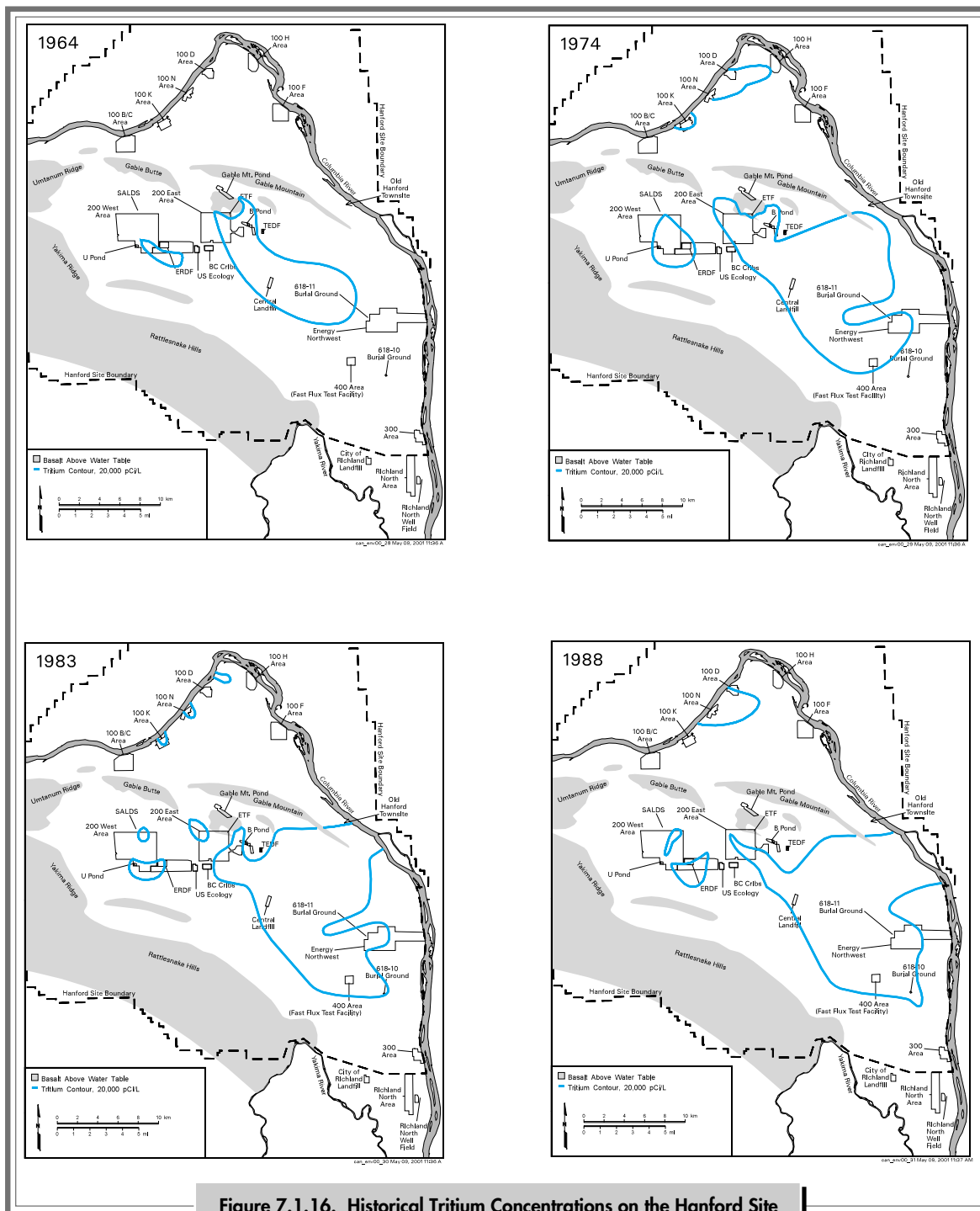Figure 7.1.15. Tritium Concentrations in Well 699-24-33, 1987 through 2000

was discharging to the Columbia River several kilometers south of the Old Hanford Townsite. The tritium plume continued to expand in the southeastern part of the Hanford Site. By 1995, tritium at concentrations exceeding 20,000 pCi/L was entering the Columbia River along greater portions of the shoreline extending between the Old Hanford Townsite and the 300 Area. Tritium levels did not change significantly between 1995 and 2000.
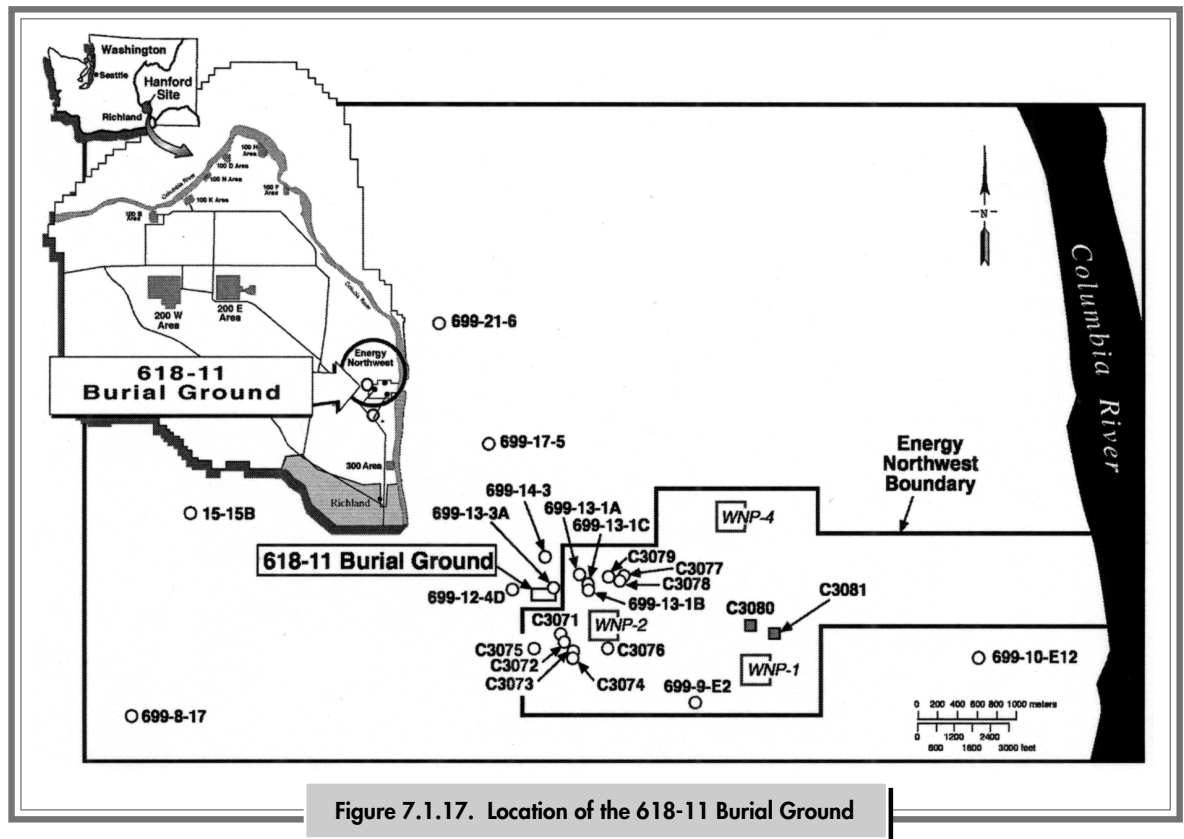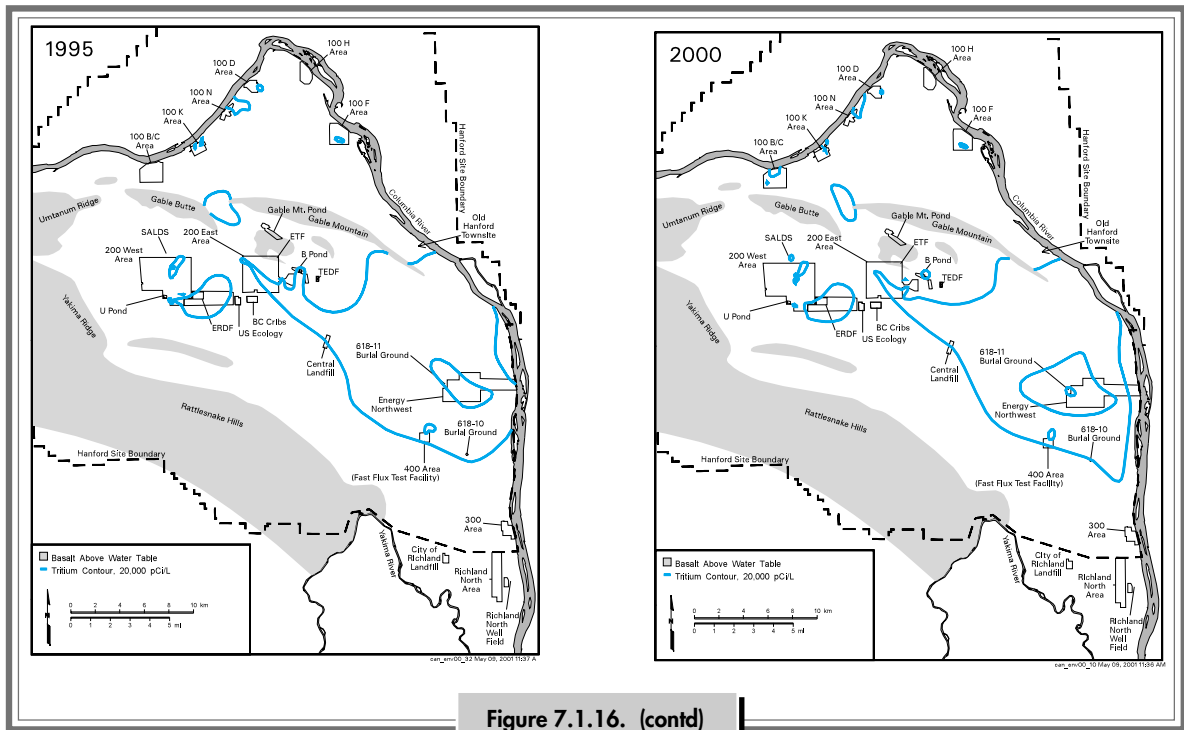
Tritium is also found at levels above the drinking water standard in the northwestern part of the 200-East Area (see Figure 7.1.11). This plume appears to extend to the northwest through the gap between Gable Mountain and Gable Butte where a pulse of tritium also occurs at levels above the drinking water standard. Sources of tritium in these areas include waste sites in the vicinity of B Plant. The tritium distribution to the northwest and southeast of the 200-East Area indicates a divide in groundwater flow direction across the 200-East Area.

The highest tritium concentrations measured in Hanford Site groundwater in 2000 were in one

well (699-13-3A) near the 618-11 burial ground. Tritium levels at this well ranged from 5.69 million pCi/L to 8.38 million pCi/L in 2000. This burial ground is located west of the Energy Northwest reactor complex in the eastern 600 Area (Figure 7.1.17). The burial ground was active from 1962 to 1967 and received a variety of low- and high-level waste from the 300 Area. A special investigation began in 2000 to define the source of the high tritium levels. The Phase I sampling results are reported in PNNL-13228 and are available on the Groundwater Monitoring Project website at http://www.hanford-site.pnl.gov/groundwater.

Phase II of the investigation began in summer 2000 and included a soil gas survey to determine the distribution of tritium in groundwater and the vadose zone. The highest tritium concentration in groundwater estimated from the soil gas results was ~24 million pCi/L at the northeastern corner of the burial ground. The distribution of tritium in the vadose zone is discussed in Section 7.2.
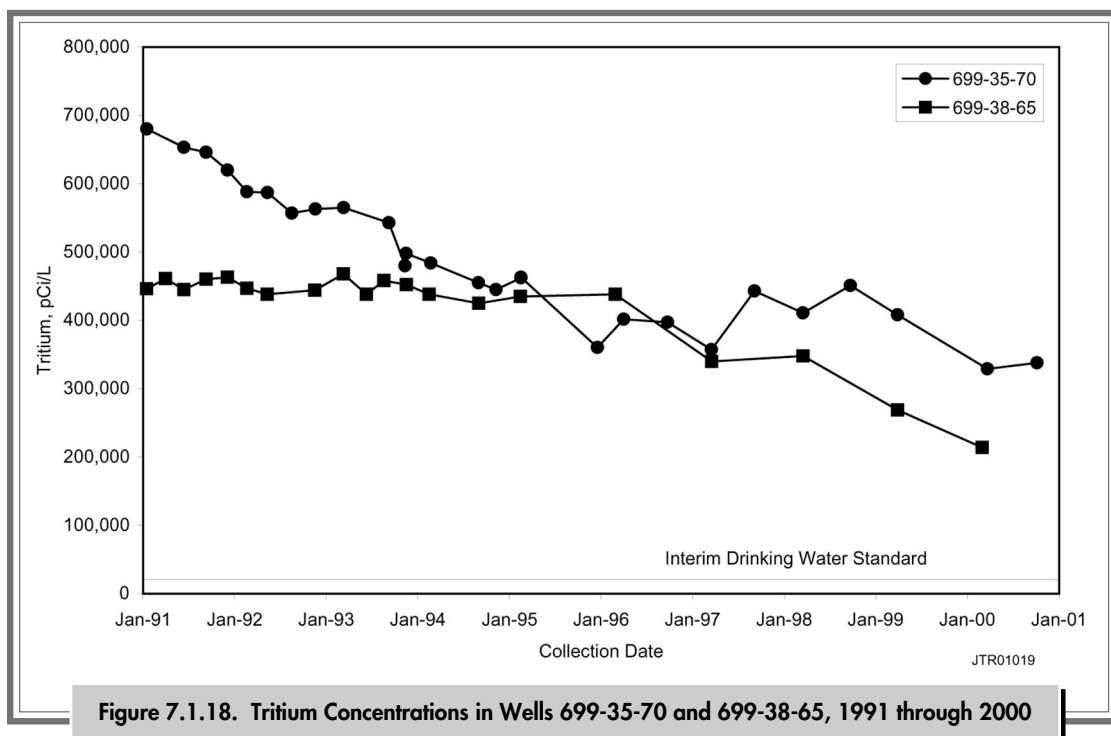
Figure 7.1.16. Historical Tritium Concentrations on the Hanford Site

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Figure 7.1.16. (contd)

Figure 7.1.17. Location of the 618-11 Burial Ground

Tritium in the 200-West Area. Tritium from sources near the Reduction-Oxidation Plant forms the most extensive plume associated with the 200-West Area. The Reduction-Oxidation Plant is located in the southeastern part of the 200-West Area and operated from 1951 through 1967. This plume extends into the 600 Area east of the 200-West Area to US Ecology's facility and the eastern part of the plume curves to the north (see Figure 7.1.11). However, the highest tritium concentrations in the plume are declining, as illustrated in Figure 7.1.18. The maximum concentration in this plume east of the Reduction-Oxidation Plant in 2000 was 338,000 pCi/L. The movement of plumes in the 200-West Area is slow because the Ringold Formation sediment that underlies the area has low permeability and restricts flow. Movement of the plumes in the 200-West Area also is slow because of declining hydraulic gradients. Tritium concentrations exceeded the drinking water standard in much of the plume, including a small area near the former 216-S-25 crib and S-SX tank farm upgradient of the Reduction-Oxidation Plant. The maximum tritium concentration in these areas in 2000 was 502,000 pCi/L adjacent to the former 216-S-25 crib. Concentrations continue to increase slowly in the eastern part of the plume near the US Ecology facility, but at levels less than the drinking water standard.

A smaller tritium plume covers much of the northern part of the 200-West Area and extends to the northeast (see Figure 7.1.11). This plume is associated with former T Plant waste sites, including TY tank farm, the 242-T evaporator, and inactive disposal cribs. The highest tritium concentration detected in the 200-West Area was 2.94 million pCi/L just east of the TX and TY tank farms near the 216-T-26 crib. Tritium concentrations at this location, which exceeded the derived concentration guide in 2000, have increased significantly since 1998. The area where the drinking water standard was exceeded extends northeast past the northern boundary of the 200-West Area.

Tritium concentrations in the top of the unconfined aquifer continued to decline in 2000

Figure 7.1.18. Tritium Concentrations in Wells 699-35-70 and 699-38-65, 1991 through 2000

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at wells monitoring the State-Approved Land Disposal Site just north of the 200-West Area. The maximum concentration decreased from 610,000 pCi/L in 1999 to 340,000 pCi/L in 2000, which exceeded the drinking water standard. However, tritium concentrations continued to rise in the deeper portion of the unconfined aquifer. The maximum tritium concentration in the deeper part of the unconfined aquifer was 850,000 pCi/L in 2000. The lower concentrations in the top of the unconfined aquifer in 2000 reflect the reduced concentration levels in effluent discharged to this facility over the past ~2 years (PNNL-13058). By the end of December 2000, ~325 curies of tritium and over 375 million liters (99 million gallons) of treated effluent containing tritium had been discharged to this facility since operations began in 1995.
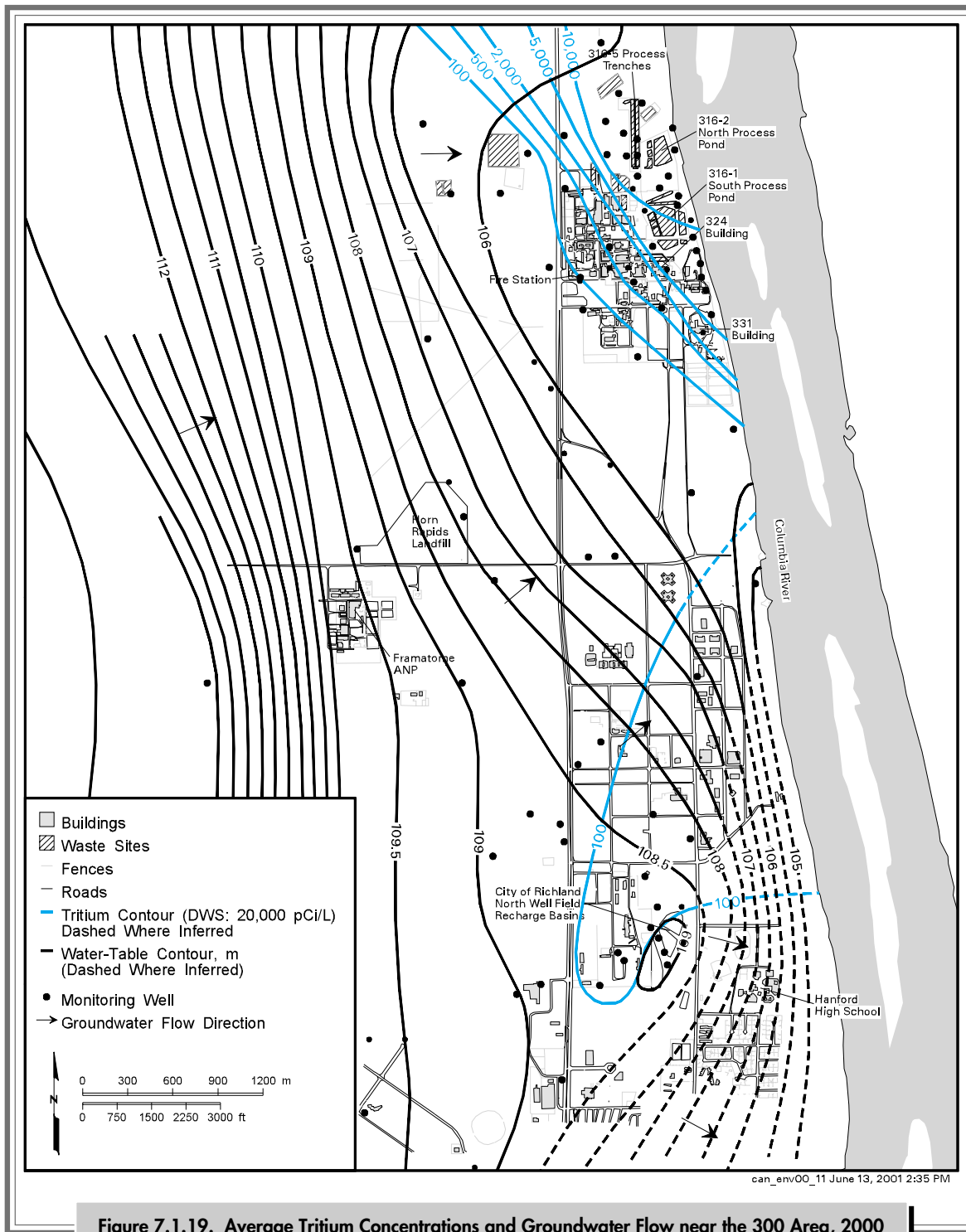
Tritium in the 300 Area. The eastern portion of the tritium plume that emanates from the 200-East Area continues to move to the east-southeast and discharge into the Columbia River (see Figure 7.1.11). The southern edge of the tritium plume extends into the 300 Area, as shown in Figure 7.1.19. Figure 7.1.19 shows that tritium concentrations decrease from greater than 10,000 pCi/L in the northeastern part of the 300 Area to less than 100 pCi/L in the southwestern part of the 300 Area. This distribution is nearly the same as the 1999 distribution. Although tritium in the 300 Area is below the drinking water standard, a concern has been the potential migration of tritium to a municipal water supply to the south. The municipal water supply consists of the city of Richland's well field and recharge ponds (see Figure 7.1.19). The highest tritium level detected south of the 300 Area was 546 pCi/L near the well field. Monitoring data indicate that the Hanford Site tritium plume has not reached the municipal water supply.

The tritium plume is not expected to impact the well field because of the influence of groundwater flow from the Yakima River, recharge from agricultural irrigation, and recharge from infiltration ponds at the well field (see Figure 7.1.19). The Yakima River is at a higher elevation than the water table and recharges the groundwater in this area. Groundwater flows from west to east (see Figure 7.1.19), minimizing the southward movement of the contaminant plume. Recharge from agricultural irrigation occurs south of the Hanford Site boundary and contributes to eastward flow. The recharge ponds are supplied with Columbia River water, which infiltrates to the groundwater. The amount of recharge water exceeded the amount pumped at the well field by a factor of at least 2:1 in 2000, resulting in groundwater flow away from the well field. Recharge creates a mound that further ensures that tritium-contaminated groundwater will not reach the well field.

Tritium in the 400 Area. The tritium plume that originated in the 200-East Area extends under the 400 Area. The maximum concentration detected in this area during 2000 was 30,300 pCi/L in the northern part of the 400 Area. Tritium levels in the primary (499-S1-8J) and backup (499-S0-7 and 499-S0-8) water supply wells did not exceed the annual average drinking water standard of 20,000 pCi/L in 2000. Tritium levels in these wells did not exceed the drinking water standard in any month. The water supply wells are also located in the northern part of the 400 Area. Additional information on the 400 Area water supply is provided in Section 4.3.

Iodine-129. Iodine-129 has a relatively low drinking water standard (1 pCi/L), has the potential to accumulate in the environment as a result of long-term releases from nuclear fuel reprocessing facilities (Soldat 1976), and has a long half-life (16 million years). The iodine-129 plume at levels exceeding the drinking water standard is extensive in the 200 and 600 Areas. No groundwater samples showed iodine-129 concentrations above the 500-pCi/L derived concentration guide in 2000. Iodine-129 may be released as a vapor during fuel dissolution and during other elevated temperature processes and, thus, may be associated

Figure 7.1.19. Average Tritium Concentrations and Groundwater Flow near the 300 Area, 2000

Legend:

- Buildings
- Waste Sites
- Fences
- Roads
- Tritium Contour (DWS: 20,000 pCi/L)
  Dashed Where Inferred
- Water-Table Contour, m
  (Dashed Where Inferred)
- Monitoring Well
- Groundwater Flow Direction

Scale:
0 300 600 900 1200 m
0 750 1500 2250 3000 ft

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Map labels: 316-5 Process Trenches, 316-2 North Process Pond, 316-1 South Process Pond, 324 Building, 331 Building, Fire Station, Columbia River, Horn Rapids Landfill, Framatome ANP, City of Richland North Well Field Recharge Basins, Hanford High School

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with process condensate waste. At the Hanford Site, the main contributor of iodine-129 to groundwater is past-practice liquid discharges to cribs in the 200 Areas. Iodine-129 has essentially the same high mobility in groundwater as tritium. The highest level of iodine-129 detected in 2000 on the Hanford Site was 63.9 pCi/L near the T, TX, TY tank farms.

Iodine-129 in the 200-East Area. The highest iodine-129 concentrations in the 200-East Area are in the southeast near the Plutonium-Uranium Extraction Plant and in the northwest in the vicinity of B Plant (Figure 7.1.20). The maximum level of iodine-129 detected in 2000 in the 200-East Area was 10.8 pCi/L south of the Plutonium-Uranium Extraction Plant near the 216-A-36B crib. Iodine-129 concentrations near this area are declining slowly or are stable. The iodine-129 plume extends from the Plutonium-Uranium Extraction Plant area southeast into the 600 Area and appears coincident with the tritium plumes (see Figure 7.1.11). The plume appears smaller than the tritium plume because of the lower initial concentration of iodine-129. The iodine-129 contamination can be detected as far to the east as the Columbia River but at levels below the drinking water standard. Data indicate that the portion of the iodine-129 plume at levels above the drinking water standard moved 2.5 kilometers (1.6 miles) toward the Columbia River between 1990 and 2000. The plume likely had the same sources as the tritium plume. Iodine-129 also is present in groundwater at levels above the drinking water standard in the northwestern 200-East Area; however, a definite source for this plume has not been determined. The maximum level detected in this area in 2000 was 7.3 pCi/L. This plume extends northwest into the gap between Gable Mountain and Gable Butte.

Iodine-129 in the 200-West Area. The distribution of iodine-129 in Hanford Site groundwater is shown in Figure 7.1.20. The highest level detected on the site in 2000 was 63.9 pCi/L near the T, TX,

and TY tank farms in the northern part of the 200-West Area. This level occurs in a plume that extends northeast toward T Plant. The iodine-129 plume, which is generally coincident with the technetium-99 and tritium plumes in this area, most likely originates from the 242-T evaporator located between the TX and TY tank farms. A much larger iodine-129 plume occurs in the southeastern part of the 200-West Area, which originates near the Reduction-Oxidation Plant, and extends east into the 600 Area. This plume is essentially coincident with the tritium plume, though there appears to be a contribution from cribs to the north near U Plant. In 2000, the maximum concentration detected in this plume was 35.1 pCi/L in the 600 Area east of the Reduction-Oxidation Plant. Iodine-129 levels in this plume did not change significantly between 1999 and 2000.

Technetium-99. Technetium-99, which has a half-life of 210,000 years, was produced as a high-yield fission byproduct and was present in waste streams associated with fuel reprocessing. Past reactor operations may also have resulted in the release of some technetium-99 associated with fuel element breaches. Technetium-99 is typically associated with uranium through the fuel processing cycle, but uranium is less mobile in groundwater. Under the chemical conditions that exist in Hanford Site groundwater, technetium-99 is normally present in solution as anions that sorb poorly to sediments. Therefore, technetium-99 is very mobile in site groundwater.

The derived concentration guide is 100,000 pCi/L and the interim drinking water standard is 900 pCi/L for technetium-99. Technetium-99 was found at concentrations greater than the 900-pCi/L interim drinking water standard in the 200-East and 200-West Areas. The highest level measured on the Hanford Site in 2000 was 72,300 pCi/L near the SX tank farm.

Technetium-99 in the 200-East Area. Groundwater in the northwestern part of the
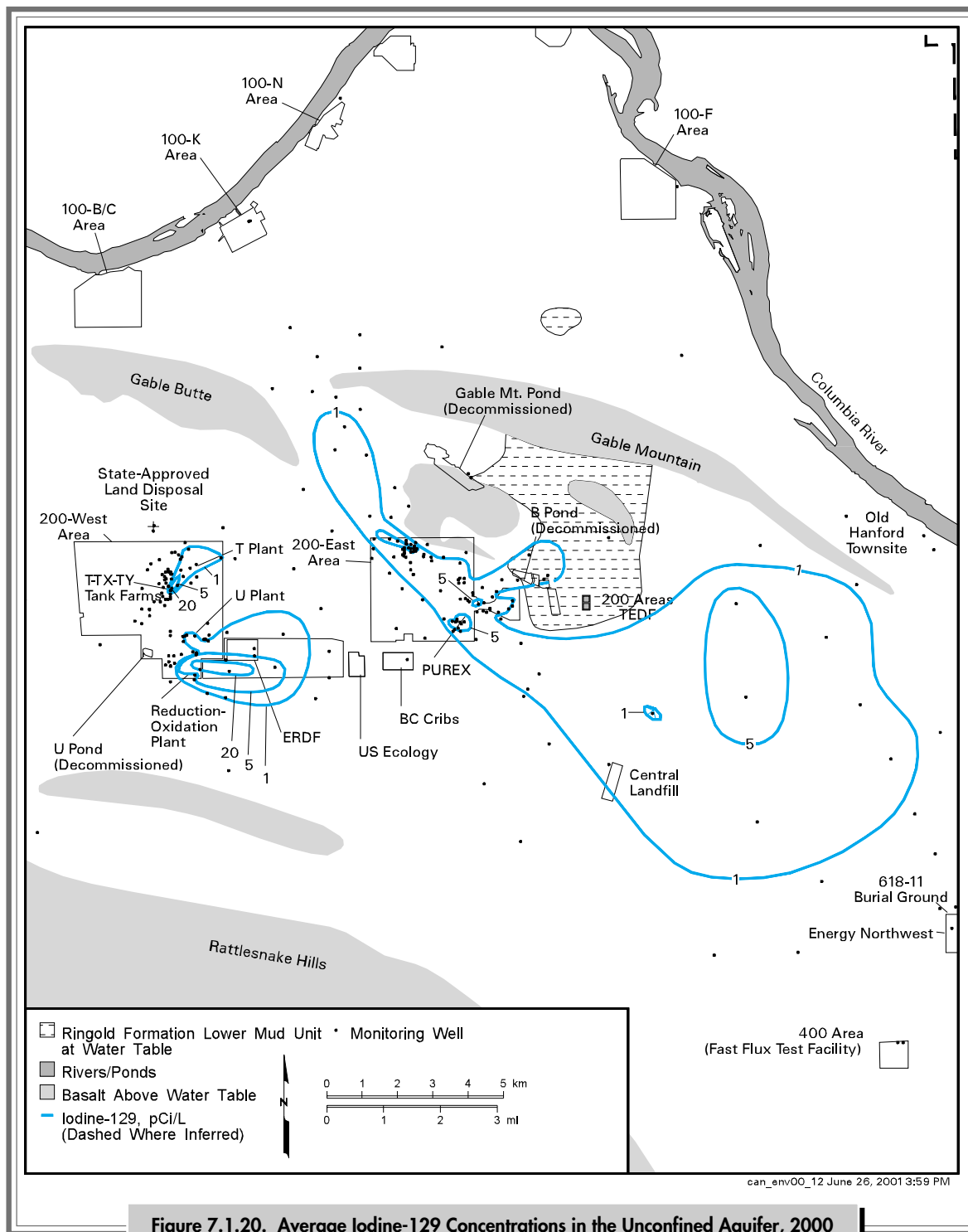
Figure 7.1.20. Average Iodine-129 Concentrations in the Unconfined Aquifer, 2000

Legend:

☐ Ringold Formation Lower Mud Unit at Water Table
• Monitoring Well
▨ Rivers/Ponds
☐ Basalt Above Water Table
— Iodine-129, pCi/L (Dashed Where Inferred)

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200-East Area and a part of the 600 Area north of the 200-East Area contains technetium-99 at concentrations above the interim drinking water standard (Figure 7.1.21). The source of the technetium contamination was apparently the BY cribs (Section 2.9.1 in PNNL-13116). However, some of this contamination is believed to originate from tank farms B, BX, and BY (PNNL-11826). Technetium-99 concentrations continued to increase in several wells monitoring tank farms B, BX, and BY in 2000. The maximum concentration in the 200-East Area in 2000 occurred at the BY cribs at a level of 13,300 pCi/L. The maximum technetium-99 concentration in the plume north of the 200-East Area in 1999 was 3,200 pCi/L. This plume appears to be moving north through the gap between Gable Mountain and Gable Butte.

Technetium-99 in the 200-West Area. The largest technetium-99 plume in the 200-West Area originates from cribs that received effluent from U Plant and extends into the 600 Area to the east (Figure 7.1.22). The technetium plume is approximately in the same location as the uranium plume because technetium-99 and uranium, which are typically associated with the same fuel reprocessing cycle, were disposed to the same 216-U-1, 216-U-2, and 216-U-17 cribs. Although a pump-and-treat system reduced technetium-99 concentrations in most of the plume near the 216-U-17 crib to levels below the 9,000-pCi/L cleanup level between 1999 and 2000, an area of increasing concentrations occurs in the northwestern part of the plume near the former injection well. This well is located approximately midway between the 216-U-1, 216-U-2, and the 216-U-17 cribs. The maximum level in this plume was detected at a concentration of 27,700 pCi/L. The pump-and-treat system removed 7.3 kilograms (0.0161 pound) of technetium-99 in 2000.
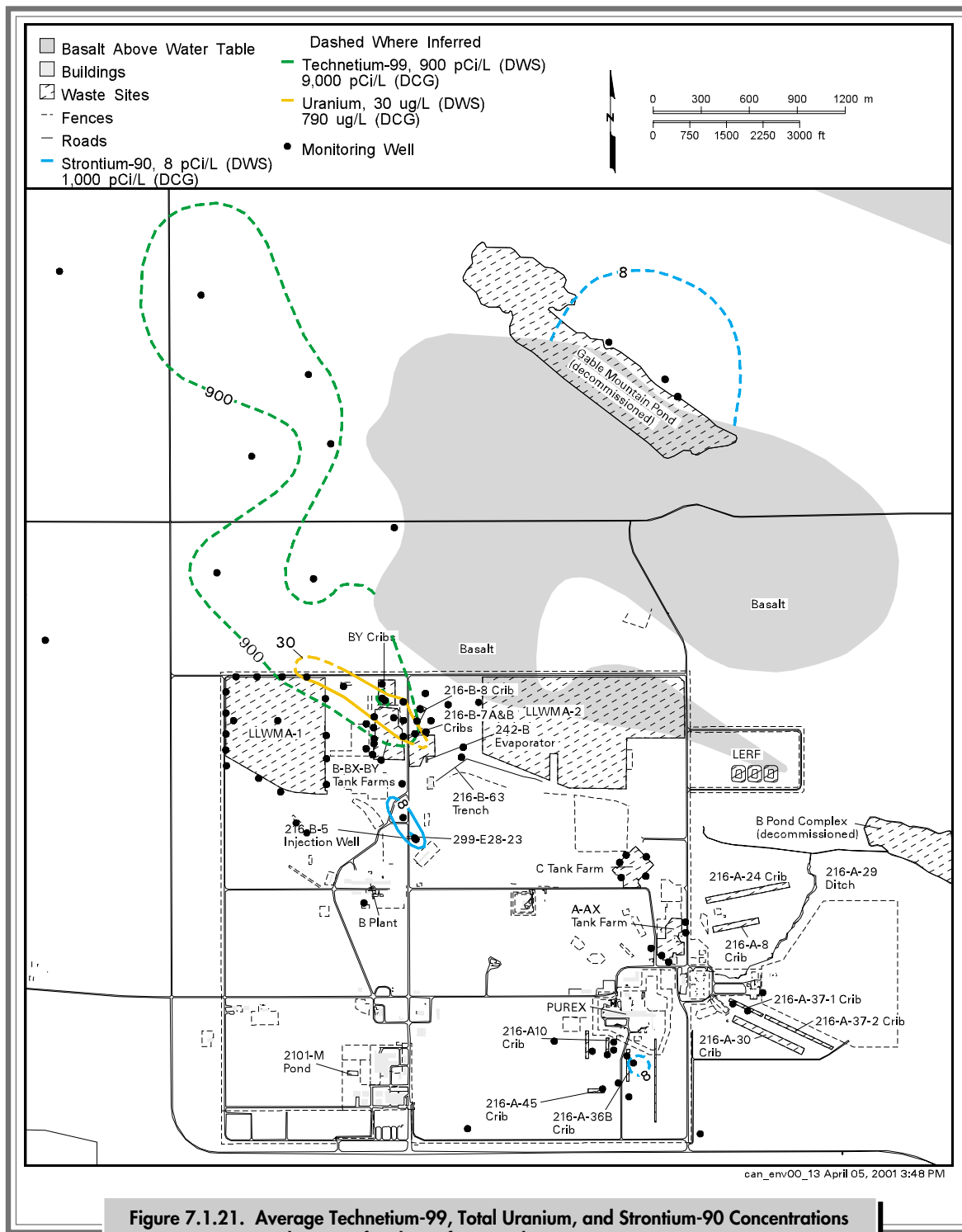
Several wells that monitor tank farms T, TX, and TY consistently showed technetium-99 concentrations above the interim drinking water standard in 2000 (see Figure 7.1.22). The highest was
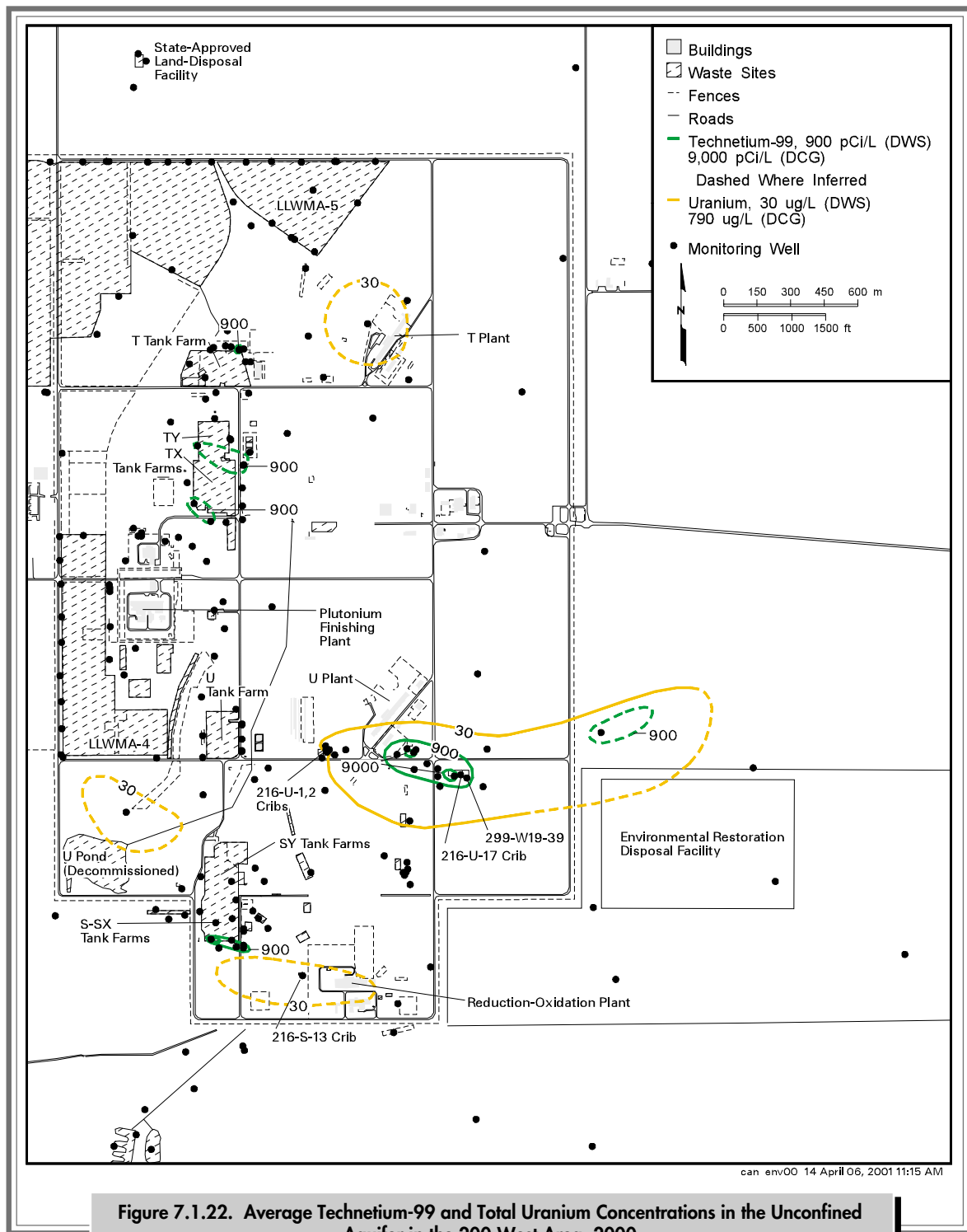
7,450 pCi/L east of the TX and TY tank farms, where technetium-99 levels have been increasing in recent years. The 200-ZP-1 pump-and-treat operation immediately to the south is having a significant influence on the distribution of contaminants beneath the TX and TY tank farms. A large cone of depression in the water table is resulting in contaminants from beneath the tank farms to be drawn toward the pump-and-treat system.

In the northeastern corner of T tank farm, technetium-99 levels were above the interim drinking water standard in two wells. The maximum in this area was 4,470 pCi/L in 2000. This was a decrease from the maximum of 7,110 pCi/L in 1999. The sources of the technetium-99 contamination include tank farms T, TX, and TY (PNNL-11809).

Technetium-99 contamination in small areas in the southern part of the 200-West Area originates near tank farms S and SX and the 216-S-13 crib. Multiple sources of technetium-99 contribute to groundwater contamination in this area (PNNL-11810; PNNL-13441). The maximum level detected was 72,300 pCi/L in the southwestern corner of tank farm SX, where a gradual upward trend in technetium-99 occurs. This was the highest technetium-99 concentration detected on the Hanford Site in 2000.

Total Uranium. There were numerous possible sources of uranium released to the groundwater at the Hanford Site in the past, including fuel fabrication, fuel reprocessing, and uranium recovery operations. Uranium may exist in several states, including elemental uranium or uranium oxide as well as tetravalent and hexavalent cations. Only the hexavalent form has significant mobility in groundwater, largely by forming dissolved carbonate species. Uranium mobility is, thus, dependent on oxidation state, pH, and the presence of carbonate. Uranium is observed to migrate in site groundwater but is retarded relative to more mobile species such as technetium-99 and tritium. The

7.40

Figure 7.1.21. Average Technetium-99, Total Uranium, and Strontium-90 Concentrations in the Unconfined Aquifer near the 200-East Area, 2000

7.41

Figure 7.1.22. Average Technetium-99 and Total Uranium Concentrations in the Unconfined Aquifer in the 200-West Area, 2000

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EPA's drinking water standard for uranium is 30 μg/L[a], which is protective of both chemical toxicity and cancer risk. The derived concentration guide that represents an annual effective dose equivalent of 100 mrem/yr is 790 μg/L for uranium.

Total uranium has been detected at concentrations greater than the drinking water standard in portions of the 100, 200, 300, and 600 Areas. The highest levels detected at the Hanford Site in 2000 were in the 200-West Area near U Plant, where uranium levels were 1,900 μg/L and exceeded the derived concentration guide.

Total Uranium in the 100 Areas. Uranium was detected at levels exceeding the 30-μg/L drinking water standard in a small area in the 100-H Area. The maximum detected in 2000 was 49.3 μg/L between the 183-H solar evaporation basins and the Columbia River. Concentrations of uranium (and associated technetium-99) in the 100-H Area usually fluctuate in response to changes in groundwater levels. Near the river, low groundwater levels are usually associated with higher concentrations. Past leakage from the basins is the source of the 100-H Area uranium contamination.

Total Uranium in the 200-East Area. In the 200-East Area, uranium contamination at levels greater than the drinking water standard is limited to isolated areas associated with B Plant. The uranium distribution in 2000 indicates the highest concentrations were in the vicinity of the B, BX, and BY tank farms; BY cribs; and 216-B-5 injection well that has been inactive since 1947. The highest concentration detected was 515 μg/L west of the BY tank farm (southwest of the BY cribs). The uranium plume has a narrow northwest-southeast shape. Though unclear, a likely source of the uranium contamination is from the tank farm area.

Total Uranium in the 200-West Area. The highest uranium concentrations in Hanford Site

groundwater occurred near U Plant, at wells downgradient from the inactive 216-U-1 and 216-U-2 cribs and adjacent to the 216-U-17 crib (see Figure 7.1.22). The maximum detected in this area and on the Hanford Site in 2000 was 1,900 μg/L adjacent to the 216-U-17 crib. The uranium plume, which extends into the 600 Area to the east, is approximately in the same location as the technetium-99 plume discussed above. Uranium and technetium-99 were typically associated with the same fuel reprocessing cycle and were disposed to the same cribs. However, uranium is less mobile than technetium-99 because of its stronger sorption to the sediment. A greater proportion of the uranium contamination remains at or near the source area. The high concentrations exceeded the derived concentration guide for uranium. A pump-and-treat system continued to operate in 2000 to remove uranium from groundwater. The pump-and-treat system removed 17.0 kilograms (37.6 pounds) of uranium in 2000.

Other areas with uranium contamination at levels above the drinking water standard are also shown in Figure 7.1.22, including areas west and northwest of the Reduction-Oxidation Plant. Uranium concentrations in those areas are considerably lower than the concentrations detected near U Plant. The maximum uranium in these areas was 30.9 μg/L immediately southeast of tank farms S and SX (northwest of the Reduction-Oxidation Plant). In the northern part of the 200-West Area, a localized area of uranium contamination occurs near T Plant, where concentrations were above the drinking water standard at a maximum level of 454 μg/L.

Total Uranium in the 300 Area. A plume of uranium contamination exists near uranium fuel fabrication facilities and inactive sites known to have received uranium waste. The plume extends downgradient from inactive liquid waste disposal

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(a) The final rule for the uranium drinking water standard was promulgated on December 7, 2000, and becomes effective on December 8, 2003 (40 CFR Parts 9, 141, and 142).

facilities to the Columbia River (Figure 7.1.23). The major source of the contamination is the inactive 316-5 process trenches, as indicated by the distribution of the uranium concentrations downgradient from these trenches. The maximum concentration detected at this area in 2000 was 234 µg/L near the Columbia River. Because wastewater is no longer discharged to the 316-5 process trenches, elevated concentrations at the south end of the process trenches indicate that the soil column contributes uranium contamination to the groundwater. Uranium levels in the 300 Area fluctuate annually but show an overall decline. The annual fluctuation in uranium levels is caused by river stage changes, which results in mobilization of more uranium during high river stages in spring and less uranium during low river stages in fall or early winter.

A localized area of elevated levels of uranium between the 324 Building and the Columbia River showed a maximum concentration of 152 µg/L in 2000 (see Figure 7.1.23). In recent years, the elevated area of uranium near this building has moved downgradient with groundwater flow to a position adjacent to the Columbia River.

Total Uranium in the 600 Area. A well southeast of the 400 Area (adjacent to Route 4S) had a maximum uranium concentration of 46.7 µg/L in 2000. Uranium levels have declined slightly in this well in recent years. The contamination at this well is attributed primarily to the nearby inactive 316-4 crib. The retired 618-10 burial ground is also located near this well. A single uranium result from a well near the 618-11 burial ground in the 600 Area was 30.8 µg/L in 2000.

Strontium-90. Strontium-90 was produced as a high-yield fission product and was present in waste streams associated with past fuel reprocessing. Reactor operations also resulted in the release of some strontium-90 associated with fuel element breaches. Strontium-90 mobility in Hanford Site groundwater is reduced by adsorption onto sediment

particles. However, strontium-90 is moderately mobile in groundwater because its adsorption is much weaker than for other radionuclides such as cesium-137 and plutonium. Because of sorption, a large proportion of the strontium-90 in the subsurface is not present in solution. The half-life of strontium-90 is 29.1 years.

In 2000, strontium-90 concentrations greater than the 8-pCi/L drinking water standard were found in one or more wells in each of the 100, 200, and 600 Areas. Levels of strontium-90 were greater than the 1,000-pCi/L derived concentration guide in the 100-K and 100-N Areas. The 100-N Area had the widest distribution with the highest concentrations detected at the Hanford Site during 2000. The maximum concentration was 17,700 pCi/L.

Strontium-90 in the 100 Areas. Strontium-90 concentrations greater than the drinking water standard extend from the B Reactor to the Columbia River in the northeastern part of the 100-B/C Area. The highest concentrations continued to be found in wells near the inactive 116-B-1 and 116-C-1 trenches and trends indicate concentration levels did not change significantly in 2000. The maximum concentration detected was 65.6 pCi/L near the inactive 116-C-1 trench. The sources for the strontium-90 appear to be liquid waste disposal sites near B Reactor and liquid overflow trenches near the Columbia River (DOE/EIS-0119F).

Strontium-90 is not widely distributed in the 100-D Area. Strontium-90 levels were consistently greater than the drinking water standard in one well near the inactive D Reactor fuel storage basin. However, this well was decommissioned in late 1999, and there were no strontium-90 data from nearby wells in 2000. Strontium-90 was detected at levels just above the drinking water standard near the former 116-D-7 retention basin in the northern part of the 100-D Area. The maximum concentration in this area was 12.3 pCi/L in 2000.
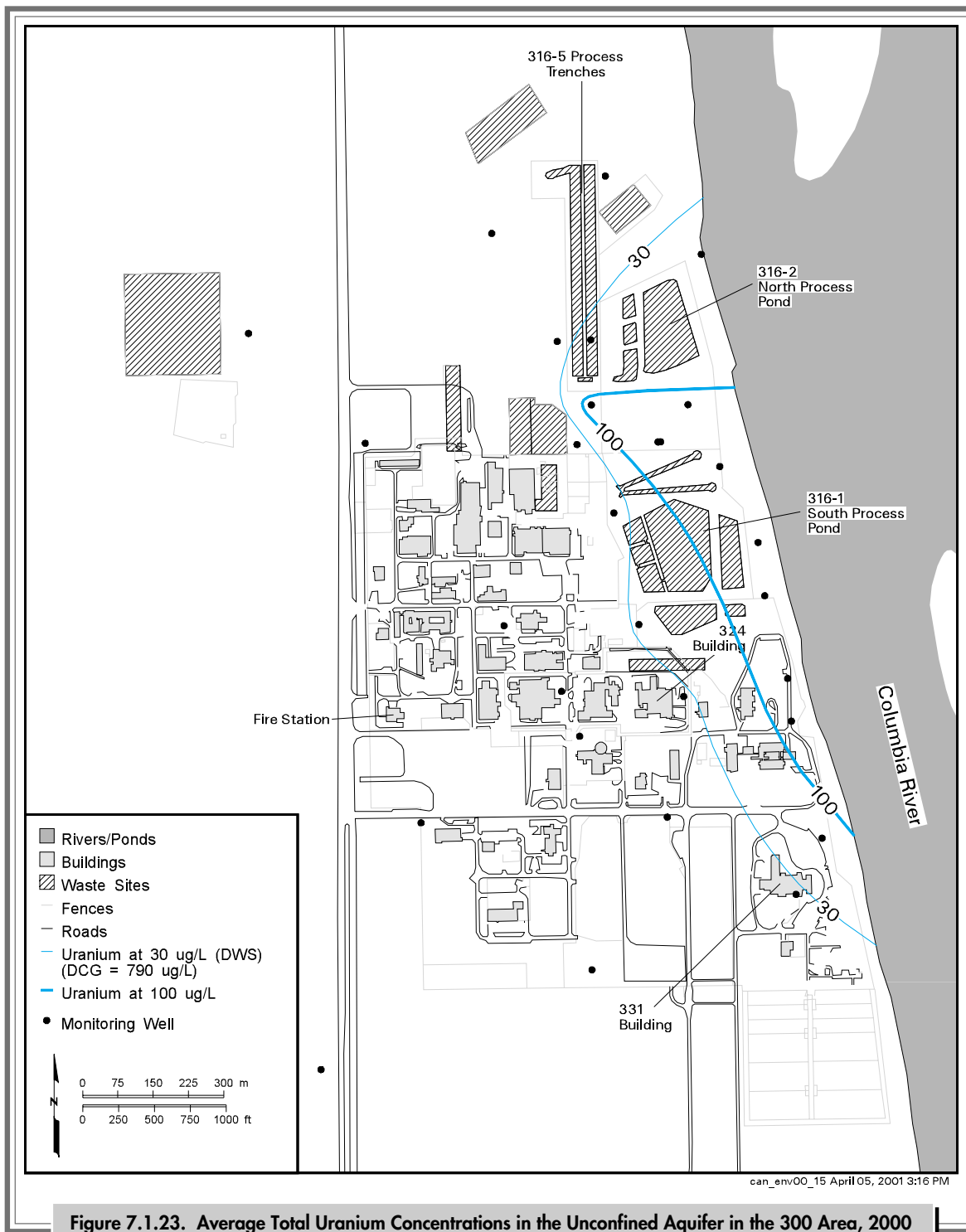
7.44

Figure 7.1.23. Average Total Uranium Concentrations in the Unconfined Aquifer in the 300 Area, 2000

316-5 Process Trenches

316-2 North Process Pond

316-1 South Process Pond

324 Building

Fire Station

331 Building

Columbia River

Legend:
- Rivers/Ponds
- Buildings
- Waste Sites
- Fences
- Roads
- Uranium at 30 ug/L (DWS) (DCG = 790 ug/L)
- Uranium at 100 ug/L
- Monitoring Well

0 75 150 225 300 m

0 250 500 750 1000 ft

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7.45

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Strontium-90 levels in the 100-D Area have not changed significantly in recent years.

Strontium-90 exceeded the drinking water standard near the 116-F-14 retention basins and 116-F-2 and 116-F-9 trenches in the eastern part of the 100-F Area. The maximum concentration detected in 2000 was 265 pCi/L. Strontium-90 levels fluctuate in the 100-F Area.

In the 100-H Area, strontium-90 contamination levels greater than the drinking water standard were present in an area adjacent to the Columbia River near the 107-H retention basin. The maximum detected in the 100-H Area in 2000 was 38 pCi/L between the retention basin and the Columbia River. The source of the contamination is past disposal of reactor coolant containing strontium-90 to the 107-H retention basin and the 107-H liquid waste disposal trench in the 100-H Area. Contaminated soil was excavated from the upper portion of the vadose zone at these facilities and disposed of to the Environmental Restoration Disposal Facility during 1999 and 2000.

Strontium-90 at levels greater than the drinking water standard continues to occur in isolated areas in the 100-K Area. These areas include fuel storage basin drain fields/injection wells associated with the KE and KW Reactors and the area between the 116-K-2 liquid waste disposal trench and the Columbia River. The maximum concentration detected in 2000 was 5,650 pCi/L at well 199-K-109A, the only well in the 100-K Area where levels were above the derived concentration guide. The original source of the strontium-90 in this well was identified as past-practice disposal to the 116-KE-3 drain field/injection well near KE Reactor (PNNL-12023). The maximum strontium-90 concentration near the disposal trench in 2000 was 38.9 pCi/L. Near the KW Reactor, strontium-90 is elevated above the drinking water standard. The concentration of strontium-90, which is sampled less than an annual frequency, has historically been approximately one half the gross
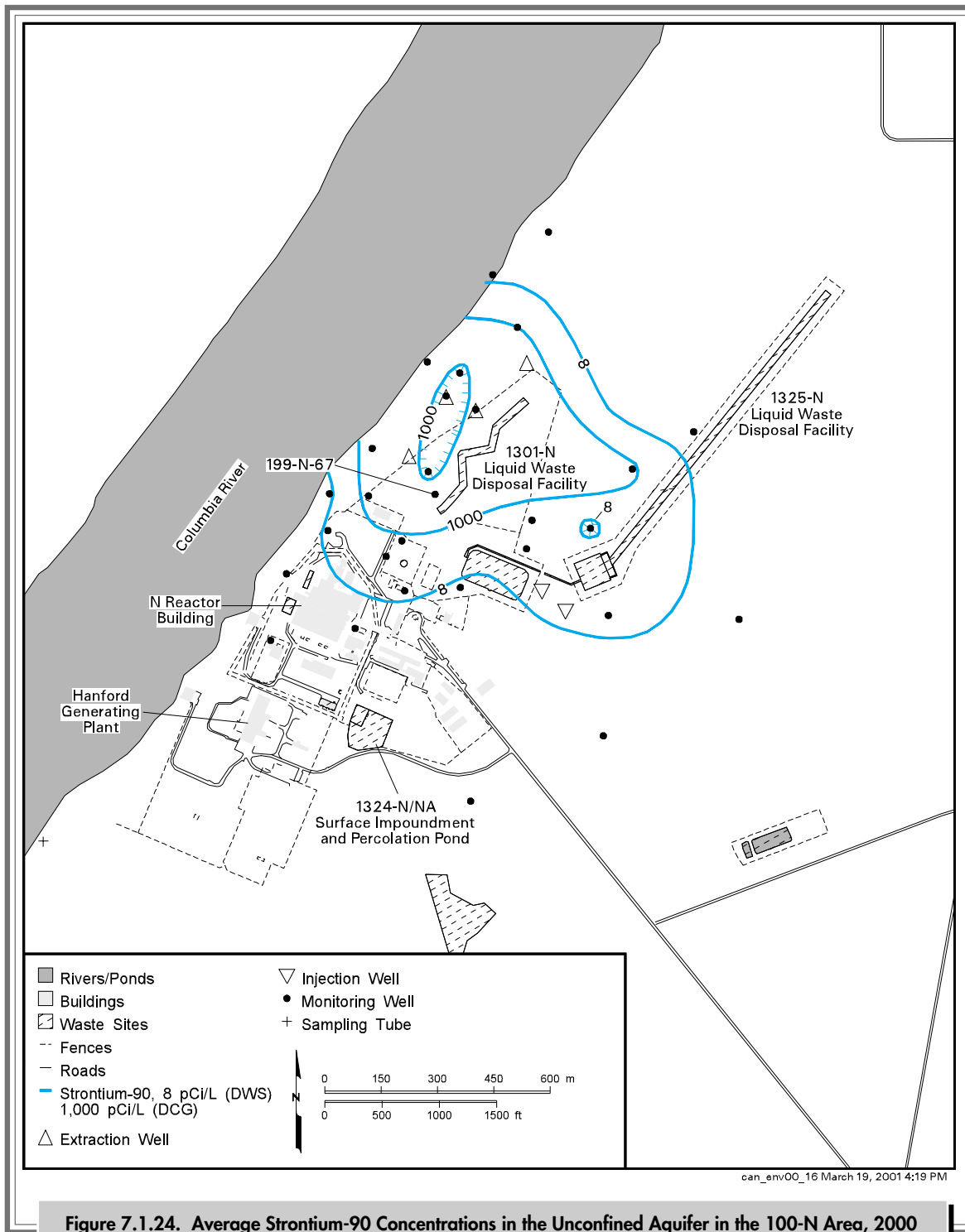
beta concentration at this location. Gross beta concentrations, which are caused primarily by decay of strontium-90, reached a maximum of 106 pCi/L near the KW Reactor in 2000.

The distribution of strontium-90 in the 100-N Area is shown in Figure 7.1.24. Strontium-90 was detected at concentrations greater than the derived concentration guide in several wells located between the 1301-N Liquid Waste Disposal Facility, a source of the strontium-90, and the Columbia River. The 1325-N Liquid Waste Disposal Facility is also a source of strontium-90 in groundwater. The maximum level detected on the Hanford Site in 2000 was 17,700 pCi/L near the head end of the 1301-N facility (well 199-N-67). The distribution of strontium-90 near this facility has not changed significantly in the past 20 years.

In the 100-N Area, strontium-90 discharges to the Columbia River through springs along the shoreline. Sections 4.2 and 3.2 give the results of spring water sampling. Because of high concentrations in wells near the river, it was expected that strontium-90 exceeded the drinking water standard at the interface between the groundwater and the river (DOE/RL-96-102). The highest strontium-90 concentration in a near-river well in 2000 was 14,700 pCi/L. Strong, positive correlations between high groundwater-level elevations and high strontium-90 concentrations in wells indicate that strontium-90 is remobilized during periods of high water levels. A pump-and-treat system continued to operate in 2000 to reduce the discharge of strontium-90 to the Columbia River.

Strontium-90 in the 200 and 600 Areas. Strontium-90 distribution in the 200-East Area is shown in Figure 7.1.21. Strontium-90 concentrations in the 200-East Area have been above the derived concentration guide in two wells near the inactive 216-B-5 injection well. However, these wells were not sampled in 2000 because of waste management issues associated with sample disposal. One of these wells, 299-E28-23, has shown a steady

Figure 7.1.24. Average Strontium-90 Concentrations in the Unconfined Aquifer in the 100-N Area, 2000

Legend:
- Rivers/Ponds
- Buildings
- Waste Sites
- Fences
- Roads
- Strontium-90, 8 pCi/L (DWS) 1,000 pCi/L (DCG)
- Extraction Well
- Injection Well
- Monitoring Well
- Sampling Tube

Map labels: Columbia River, 199-N-67, N Reactor Building, Hanford Generating Plant, 1301-N Liquid Waste Disposal Facility, 1325-N Liquid Waste Disposal Facility, 1324-N/NA Surface Impoundment and Percolation Pond

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increase in strontium-90 levels since 1990 and had a maximum concentration of 10,800 pCi/L in 1998. The maximum strontium-90 concentration detected near the injection well in 2000 was 50.4 pCi/L, which is above the 8-pCi/L drinking water standard. The former injection well received an estimated 27.9 curies of strontium-90 during 1945 and 1946 (PNL-6456). In the 200-East Area, strontium-90 was detected above the drinking water standard in one well near the Plutonium-Uranium Extraction Plant cribs. Strontium-90 levels have been stable in this well.

In the 200-West Area, strontium-90 was detected above the 8-pCi/L drinking water standard in one well near the Reduction-Oxidation Plant cribs. The maximum concentration near the cribs was 74.3 pCi/L in 2000. Strontium-90 levels have been increasing in this well in recent years.

In the 600 Area, the highest strontium-90 concentrations were detected in wells in the former Gable Mountain Pond area (see Figure 7.1.21). In one well, the level of strontium-90 rose above the derived concentration guide in 2000 to a maximum concentration of 1,210 pCi/L. Strontium-90 contamination in this area resulted from the discharge of radioactive liquid waste to the former Gable Mountain Pond during its early use.

Carbon-14. Carbon-14 concentrations occur in the 100-K Area and exceed the 2,000-pCi/L interim drinking water standard in two small plumes near the KE and KW Reactors (see Figure 7.1.12). The sources of the carbon-14 were the 116-KE-1 and 116-KW-1 condensate cribs, respectively. However, waste disposal to these cribs ended in 1971. Carbon-14 was included with tritium in the condensate wastewater disposed to the cribs. However, the distribution of carbon-14 in groundwater is not the same as for tritium because carbon-14 interacts with carbonate minerals and, thus, disperses more slowly than does tritium (PNNL-12023). The maximum concentration in 2000 was 16,300 pCi/L near the 116-KE-1 crib.

Carbon-14 levels have remained stable in most of the 100-K Area wells. The derived concentration guide for carbon-14 is 70,000 pCi/L. Carbon-14 has a long half-life of 5,730 years, which suggests that some of the carbon-14 will reach the Columbia River before it decays. A portion of the carbon-14 will likely remain fixed in carbonate minerals.

Cesium-137. Cesium-137, which has a half-life of 30 years, is produced as a high-yield fission product and is present in historic waste streams associated with fuel processing. Former reactor operations also may have resulted in the release of some cesium-137 associated with fuel element breaches. Normally, cesium-137 is strongly sorbed on soil and, thus, is not very mobile in Hanford Site groundwater. The interim drinking water standard for cesium-137 is 200 pCi/L; the derived concentration guide is 3,000 pCi/L.

Cesium-137 was detected in three wells located near the inactive 216-B-5 injection well in the 200-East Area. The injection well received waste containing cesium-137 from 1945 to 1947. Annual measurements of cesium-137 in one of these wells have consistently shown levels greater than the interim drinking water standard. However, this well was not sampled in 2000 because of waste management issues associated with sample waste. Cesium-137 levels did not change significantly in the other two wells. Cesium-137 appears to be restricted to the immediate vicinity of the former injection well.

Cobalt-60. Cobalt-60 in groundwater is typically associated with waste generated by reactor effluent disposed to the ground in the past. Cobalt-60 is normally present as a divalent transition metal cation and, as such, tends to be immobile in groundwater. However, complexing agents may mobilize it. All cobalt-60 levels in groundwater samples analyzed in 2000 were below the 100-pCi/L interim drinking water standard. The derived concentration guide for cobalt-60 is 5,000 pCi/L.

Cobalt-60 was detected in the northwestern part of the 200-East Area and the adjacent 600 Area north of the 200-East Area. These are the same areas where the technetium-99 contamination associated with the BY cribs is found. Apparently, cobalt in this plume is mobilized by reaction with cyanide or ferrocyanide in the waste stream, forming a dissolved cobalt species. The maximum concentration measured in 2000 was 78.4 pCi/L at the BY cribs. Cobalt-60 levels are increasing with associated cyanide and technetium-99 in wells near the BY cribs. Because of its relatively short half-life (5.3 years), much of the cobalt-60 in groundwater in this area has decayed to low concentrations.

Plutonium. Plutonium was released to the soil column in the past at several locations in both the 200-West and 200-East Areas. Plutonium is generally considered to sorb strongly to sediment, which limits its mobility in the aquifer. The derived concentration guide for both plutonium-239 and plutonium-240 is 30 pCi/L. Radiological analysis is incapable of distinguishing between plutonium-239 and plutonium-240; therefore, the results are expressed as a concentration of plutonium-239/240. There is no explicit drinking water standard for plutonium-239/240; however, the gross alpha drinking water standard of 15 pCi/L would be applicable at a minimum. However, if the derived concentration guide that is based on a 100-millirem dose standard is converted to the 4-millirem dose equivalent used for the drinking water standard, 1.2 pCi/L would be the relevant guideline. The half-lives of plutonium-239 and plutonium-240 are 24,000 and 6,500 years, respectively.

The only well where plutonium isotopes have been detected in groundwater above the 30-pCi/L derived concentration guide was near the inactive 216-B-5 injection well in the 200-East Area. However, this well was not sampled in 2000 because of waste management issues associated with sample waste. One other well near the inactive injection well showed a level above the 1.2-pCi/L relevant drinking water guideline. The maximum

concentration detected on the Hanford Site in 2000 was 9.4 pCi/L of plutonium-239/240. Plutonium levels did not change significantly in this well between 1999 and 2000. Because plutonium is strongly adsorbed to sediments and may have been injected into the aquifer as suspended particles, it is likely that the values measured result in part from solid rather than dissolved material. The injection well received an estimated 244 curies of plutonium-239/240 during its operation from 1945 to 1947 (PNL-6456).

Some of the results of a plutonium speciation study conducted in the 100-K Area in 1999 were available in 2000. The purpose of the research was to study the association of actinides with dissolved organic complexes in subsurface water. Plutonium in the 100-K Area was detected at extremely low concentrations. The maximum concentration of plutonium detected was ~0.0002 pCi/L.

7.1.6.2 Chemical Monitoring Results for the Unconfined Aquifer

Chemical analyses performed by various monitoring programs at the Hanford Site have identified several hazardous chemicals in groundwater at concentrations greater than their respective drinking water standards. Nitrate, chromium, and carbon tetrachloride are the most widely distributed of these hazardous chemicals and have the highest concentrations in groundwater at the Hanford Site. Hazardous chemicals that are less widely distributed and have lower concentrations in groundwater include chloroform, trichloroethene, tetrachloroethene, cis-1,2-dichloroethene, cyanide, and fluoride.

A number of parameters such as pH, specific conductance, total carbon, total organic carbon, and total organic halides are used as indicators of contamination. These are mainly discussed in Section 7.1.7. Other chemical parameters listed in

Table 7.1.4 are indicators of the natural chemical composition of groundwater and are usually not considered contaminants from operations at the Hanford Site. These include alkalinity, aluminum, calcium, iron, magnesium, manganese, potassium, silica, and sodium. Chloride and sulfate occur naturally in groundwater and can also be introduced as contaminants from site operations. There is no primary drinking water standard for chloride or sulfate. The secondary standard for each is 250 mg/L and is based on aesthetic rather than health considerations; therefore, they will not be discussed in detail. The analytical technique used to determine the concentration of metals in groundwater provides results for a number of constituents. These trace metal constituents, rarely observed at greater than background concentrations, include antimony, barium, beryllium, boron, cadmium, copper, nickel, silver, vanadium, and zinc.

The following presents a summary of the chemical constituents in groundwater at concentrations greater than existing or proposed drinking water standards (40 CFR 141 and EPA 822-R-96-001; see Appendix D).

Nitrate. Many groundwater samples collected in 2000 were analyzed for nitrate. The distribution of nitrate on the Hanford Site is shown in Figure 7.1.25; this distribution is similar to previous evaluations. Nitrate is the most widespread chemical contaminant in Hanford Site groundwater because of its mobility in groundwater and the large volumes of liquid waste containing nitrate discharged to the ground. However, the areas effected by levels greater than the drinking water standard are small. Nitrate was measured at concentrations greater than the drinking water standard (45 mg/L as nitrate ion) in portions of the 100, 200, and 600 Areas. The maximum nitrate concentration measured on the Hanford Site was 1,213 mg/L in the 200-West Area. Nitrate contamination in the unconfined aquifer reflects the extensive use of nitric acid in decontamination and chemical reprocessing operations. Nitrate is associated primarily with process condensate liquid waste, though other liquids discharged to the ground also contained nitrate. However, additional sources of nitrate, primarily associated with agriculture, occur off the site to the south, west, and southwest.

Nitrate in the 100 Areas. Nitrate was measured at concentrations exceeding the drinking water standard in all 100 Areas except the 100-B/C Area. Nitrate concentrations have generally been rising in many 100 Area wells.

Nitrate is found at levels greater than the drinking water standard in much of the 100-D Area. The highest nitrate level found in the 100-D Area in 2000 was 100 mg/L near the 120-D-1 ponds. Nitrate concentrations near the 120-D-1 ponds have shown increased trends in recent years.

Nitrate continues to be widely distributed in 100-F Area groundwater. The central and southern portions of the 100-F Area contain nitrate at levels greater than the drinking water standard. Trends continue to show increasing nitrate levels in many of the 100-F wells in 2000. The nitrate plume extends to the south and southeast into the 600 Area from upgradient sources near F Reactor. In the southern part of the 100-F Area, groundwater flow was to the southeast. The maximum nitrate detected in the 100-F Area in 2000 was 158 mg/L in the southwestern part of the 100-F Area.

A nitrate plume with concentrations above the drinking water standard lies in the eastern portion of the 100-H Area adjacent to the Columbia River. The highest concentrations are restricted to a small area downgradient of the former 183-H solar evaporation basins. The maximum nitrate detected in 2000 was 150 mg/L between the basins and the river.

Nitrate is widely distributed in the 100-K Area and has multiple sources, including septic system drain fields and past-practice disposal to the soil column. In the 100-K Area, nitrate levels decreased in a number of wells between 1999 and 2000. Only one well sample in the 100-K Area indicated a
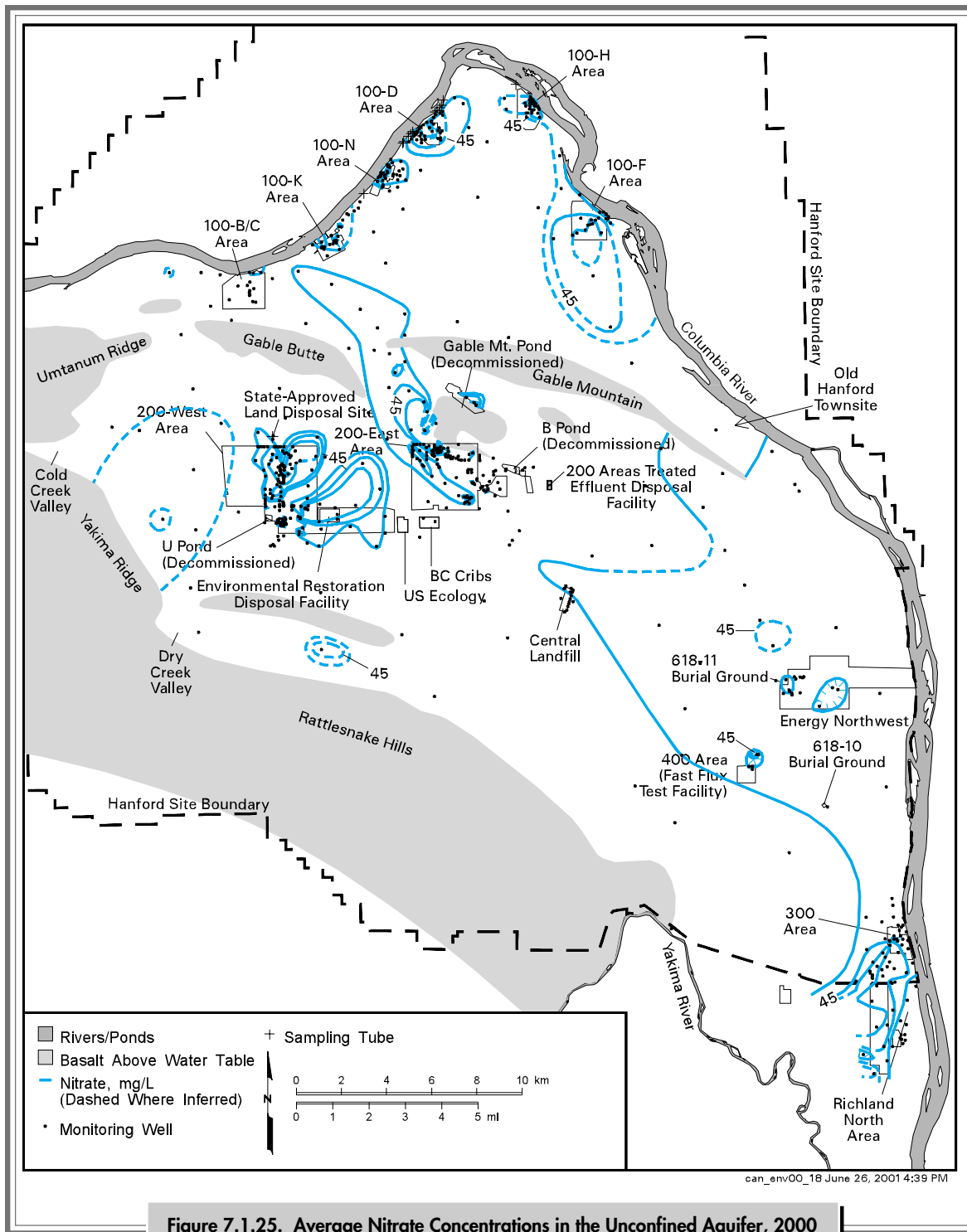
Figure 7.1.25. Average Nitrate Concentrations in the Unconfined Aquifer, 2000

Legend:
- Rivers/Ponds
- Basalt Above Water Table
- Nitrate, mg/L (Dashed Where Inferred)
- Monitoring Well
- + Sampling Tube

Map labels:
100-H Area, 100-D Area, 100-N Area, 100-K Area, 100-B/C Area, 100-F Area, Umtanum Ridge, Gable Butte, Gable Mt. Pond (Decommissioned), Gable Mountain, Columbia River, Hanford Site Boundary, Old Hanford Townsite, State-Approved Land Disposal Site, 200-West Area, 200-East Area, B Pond (Decommissioned), 200 Areas Treated Effluent Disposal Facility, Cold Creek Valley, Yakima Ridge, U Pond (Decommissioned), Environmental Restoration Disposal Facility, BC Cribs, US Ecology, Central Landfill, 618-11 Burial Ground, Energy Northwest, 618-10 Burial Ground, Dry Creek Valley, Rattlesnake Hills, 400 Area (Fast Flux Test Facility), Hanford Site Boundary, 300 Area, Yakima River, Richland North Area

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nitrate concentration that exceeded the drinking water standard in 2000. The maximum concentration detected in the 100 Areas in 2000 was 160 mg/L in a well adjacent to the KE Reactor.

Although detected over most of the 100-N Area, nitrate contamination above the drinking water standard occurs at isolated locations in the 100-N Area. The maximum in the 100-N Area was 140 mg/L in a well located between the 1301-N Liquid Waste Disposal Facility and the Columbia River.

Nitrate in the 200-East Area. The nitrate plume in the 200-East Area covers a nearly identical area to that of the tritium plume. However, the area with nitrate exceeding the drinking water standard is smaller than the area with tritium exceeding its drinking water standard. Nitrate exceeds the drinking water standard in the northern part of the 200-East Area and adjacent 600 Area to the northwest and near the Plutonium-Uranium Extraction Plant in the southeastern part of the 200-East Area. In the northern part of the 200-East Area, the plume has two parts, a western plume that extends from B Plant to the northwest and an eastern portion that extends from the BY cribs to the north and northwest. The two portions of the plume join northwest of the 200-East Area. A 2000 nitrate plume map of the northern part of the 200-East Area and the adjacent 600 Area is presented in Figure 2.9-10 of PNNL-13404.

Past disposal practices related to the BY cribs is a major contributor to the high nitrate concentrations in the northern part of the 200-East Area and adjacent 600 Area. In 2000, the highest 200-East Area concentrations were reported in several wells near the 216-B-8 crib. The maximum concentration was 695 mg/L in a well adjacent to the inactive 216-B-8 crib. Nitrate levels continue to increase near the 216-B-8 and BY cribs.

High nitrate concentrations continued to be found near liquid waste disposal facilities that received effluent from Plutonium-Uranium

Extraction Plant operations. Nitrate concentrations in wells near the inactive 216-A-10 and 216-A-36B cribs have tended to decrease in the past few years but remained greater than the drinking water standard, though these cribs were removed from service in 1987. The maximum nitrate concentration detected in this vicinity was 150 mg/L adjacent to the 216-A-36B crib.

Nitrate is also elevated in a few wells near the former Gable Mountain Pond north of the 200-East Area. In 2000, the highest measured concentration in this area was 106 mg/L.

Nitrate in the 200-West Area. Nitrate concentrations greater than the drinking water standard were widespread in groundwater beneath the 200-West Area and adjacent parts of the 600 Area. The major nitrate plumes were found in wells east of U Plant and wells in the north-central part of the 200-West Area. The widespread distribution of nitrate reflects the multiple sources in the 200-West Area. Nitrate plume maps of the 200-West and adjacent 600 Areas are presented in Figures 2.8-8 and 2.8-30 of PNNL-13404.

Near U Plant, widespread nitrate contamination is associated with the tritium and iodine-129 plumes. The nitrate contamination in this area is attributed to multiple sources, including the 216-U-1 and 216-U-2 cribs southwest of U Plant and the 216-U-17 crib southeast of U Plant. The 216-U-1 and 216-U-2 cribs received more than 1 million kilograms (2.2 million pounds) of chemicals containing nitrate during their operation from 1951 to 1967 (PNL-6456). The highest nitrate concentration measured in the plume in 2000 was 859 mg/L near the inactive 216-U-17 crib. A pump-and-treat system continued to operate in this area and 3,506 kilograms (7,729 pounds) were removed in 2000. However, nitrate is not the primary target of the pump-and-treat system.

Nitrate concentrations continued to be elevated above the drinking water standard near other inactive cribs to the south that are associated with the

U Plant and Reduction-Oxidation Plant. These elevated levels represent nitrate plumes that merge with the plume from the U Plant area. The maximum nitrate concentration reported in these areas in 2000 was 60.6 mg/L at a crib near the Reduction-Oxidation Plant.

A small, isolated plume of elevated nitrate occurs west of the Reduction-Oxidation Plant near the inactive 216-S-25 crib and S and SX tank farms, where the maximum concentration was 677 mg/L. Nitrate concentrations in this small plume appear to be associated with technetium-99.

A large area, encompassing the northern half of the 200-West Area, contains nitrate in groundwater at concentrations much greater than the drinking water standard. Wells showing the highest concentrations are located near several inactive liquid waste disposal facilities that received waste from early T Plant operations. A large amount of nitrate was disposed to these cribs (e.g., ~2.3 million kilograms [5.1 million pounds] of nitrate to the 216-T-7 crib). Maximum concentrations in these wells in 2000 ranged up to 1,213 mg/L adjacent to the 216-T-7 crib and tile field in the western portion of the T tank farm. Nitrate concentrations have increased or remained stable near these tank farms.

A smaller area of elevated nitrate concentrations above the drinking water standard is located in vicinity of the Plutonium Finishing Plant, which is in the central part of the 200-West Area. One source of the elevated nitrate is the 216-Z-9 trench, which received ~1.3 million kilograms (2.9 million pounds) of chemicals containing nitrate from 1955 to 1962. The highest reported concentration in 2000 at the Plutonium Finishing Plant was 392 mg/L adjacent to the trench, which is located east of the Plutonium Finishing Plant.

Nitrate in Other Areas. Nitrate contamination occurs near the city of Richland in the former 1100 Area, Richland North Area, and adjacent parts of the 600 Area along the southern boundary of the Hanford Site. This contamination is apparently affected by nitrate sources off the Hanford Site. These sources may include agriculture, food processing, and nuclear fuel manufacturing at offsite commercial facilities. The part of this plume with nitrate concentrations greater than the drinking water standard extends from off the site, south of the Hanford Site, to the 300 Area to the northeast. Nitrate concentrations generally continued to increase in the southern part of the Hanford Site and the adjacent area south of the Hanford Site in 2000. The maximum nitrate concentration in 2000 was 224 mg/L off the Hanford Site just south of the Hanford Site boundary (EMF-1865, Addendum 23). This nitrate is likely the result of agriculture to the west and southwest. A 2000 plume map showing detail of the nitrate distribution is presented in Figure 2.12-9 in PNNL-13404.

Although most nitrate detected on the site is the result of Hanford Site operations, elevated nitrate concentrations in the western part of the site appear to be the result of increasing agricultural activity in offsite areas (e.g., Cold Creek Valley). There is no known source of nitrate in these areas associated with site operations, and groundwater flow is from the west toward the Hanford Site facilities to the east. Nitrate levels have fluctuated considerably in wells upgradient of the 200 Areas over the past 30 years. In Cold Creek Valley, nitrate levels have been near or greater than the drinking water standard in one well since 1985. A maximum nitrate concentration of 53.1 mg/L was found in a well located just north of the Rattlesnake Hills.

Nitrate was detected at levels exceeding the drinking water standard in a well downgradient of the 400 Area process ponds. These levels, which have remained steady, were attributed to a former sanitary sewage lagoon west of the process ponds. The maximum concentration observed was 87.7 mg/L in 2000.

Chromium. Use of chromium on the Hanford Site has been extensive. In the 100 Areas, sodium dichromate was added to cooling water as a corrosion inhibitor, and some residual chromium in soil and groundwater remains from that use. Chromium was used for decontamination in the 100, 200, and 300 Areas and for oxidation state control in the Reduction-Oxidation Plant process. In the hexavalent form, chromium is present in a soluble anionic state. Thus, hexavalent chromium is freely mobile in the groundwater. The drinking water standard for chromium is 100 μg/L.

Both filtered and unfiltered samples were collected from several of the wells onsite for analyses of chromium and other metals. Unfiltered samples may contain metals present as particulate matter, whereas filtered samples are representative of the more mobile, dissolved metals. Filtered samples also may contain some colloidal particles that are fine enough to pass through the filter. Drinking water standards are based on unfiltered concentrations. However, differences in well construction and pumping practices between monitoring wells and water supply wells make it difficult to predict potential drinking water concentrations from monitoring well data when the metals are present as particulate matter. In general, filtered samples provide the best indication of groundwater contamination levels for chromium because unfiltered samples are subject to greater variability introduced by the sampling process. Chromium concentrations in filtered samples, which are considered representative of dissolved hexavalent chromium, will be used to describe the level of contamination in the discussion below.

Chromium in the 100 Areas. Chromium was detected above the drinking water standard in 2000 in the 100-D, 100-F, 100-H, 100-K, and 100-N Areas. The maximum detected concentration was 2,260 μg/L in the 100-D Area. Groundwater pump-and-treat systems continued to operate in 2000 to reduce the amount of hexavalent chromium entering the Columbia River at the 100-D,

100-H, and 100-K Areas. The purpose of the pump-and-treat systems is to prevent discharge of hexavalent chromium into the Columbia River at concentrations exceeding 11 μg/L, which is the EPA's standard for protection of freshwater aquatic life.

The chromium distribution in the 100-D Area is shown in Figure 7.1.26. Chromium contamination at levels greater than the drinking water standard is defined by two plumes. The source of the chromium plume in the southwestern part of the 100-D Area is suspected to be sodium dichromate used in the 190-DR building or disposed of in nearby waste sites. In 2000, the maximum chromium concentration from filtered samples was 2,260 μg/L in the southwestern plume near the Columbia River. The southwestern plume contains the highest concentrations of hexavalent chromium on the Hanford Site. The source of the chromium plume in the northern part of the 100-D Area is sodium dichromate released to the ground at former facilities near D Reactor. Leakage from inactive retention basins and liquid waste disposal trenches north of D Reactor may also have contributed to this chromium plume. The maximum chromium concentration in the northern plume was 393 μg/L in 2000.

In situ redox manipulation technology continues to be demonstrated in the southwestern 100-D Area to address hexavalent chromium contamination in groundwater. This technology immobilizes hexavalent chromium by reducing the soluble, more toxic, chromate ion to highly insoluble, less toxic, chromium hydroxide or iron chromium hydroxide. This is accomplished by injecting a chemical-reducing agent into closely spaced wells. Following reduction, the reagent and reaction products are pumped out of the wells. In 2000, the treatment zone was expanded by injecting the chemical-reducing agent into 10 new wells. Chromium concentrations continue to remain low in a small area of the plume. In two monitoring wells
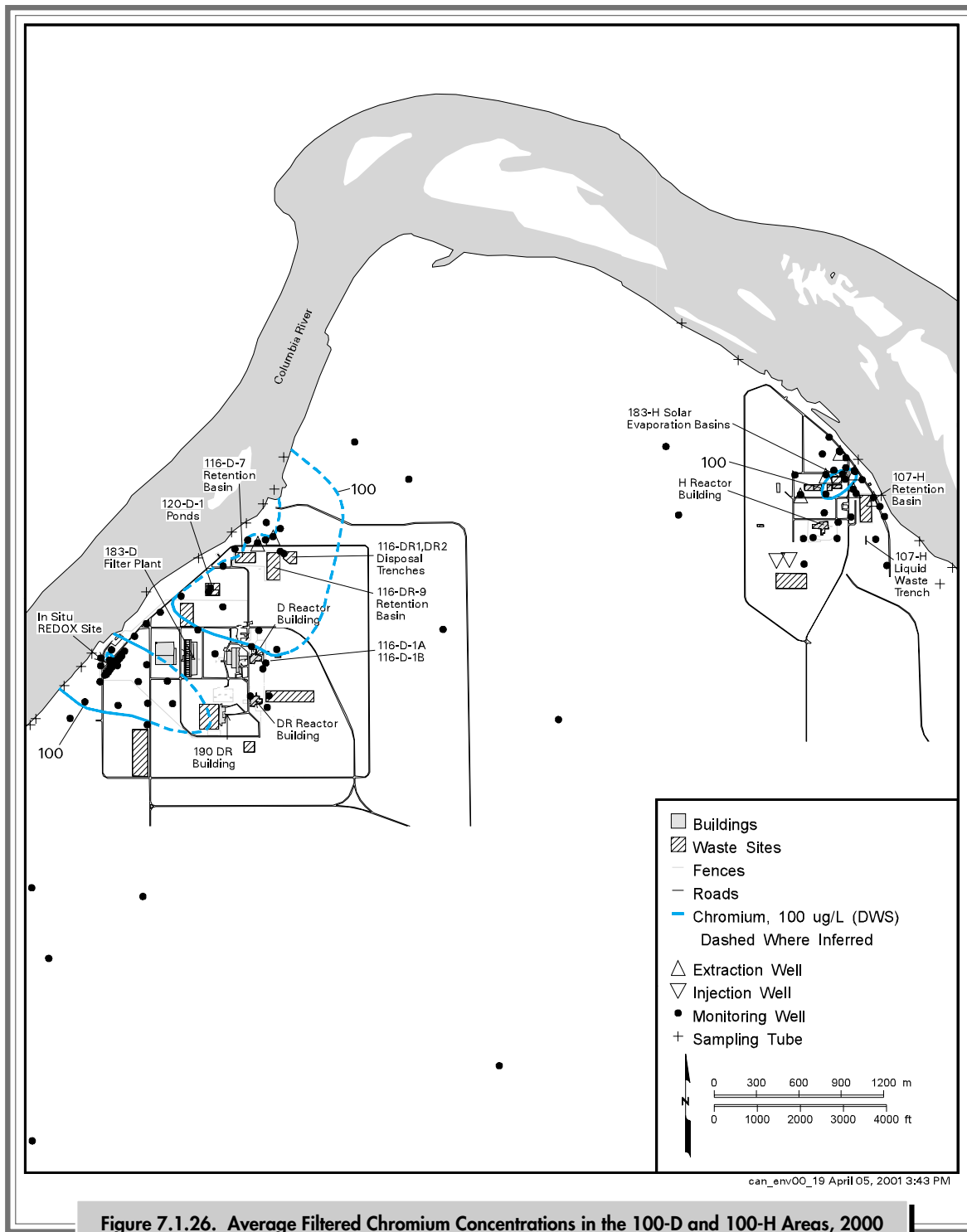
Figure 7.1.26. Average Filtered Chromium Concentrations in the 100-D and 100-H Areas, 2000

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downgradient of the redox system, chromium concentrations declined from 769 to <5 µg/L and from 912 to 370 µg/L in 2000 in response to previous injections in 1998 and 1999.

A small chromium plume in the 100-H Area contains chromium levels greater than the drinking water standard (see Figure 7.1.26). In 2000, the maximum chromium concentration from filtered samples collected from the shallow parts of the unconfined aquifer was 152 µg/L near the former 183-H solar evaporation basins. Chromium levels have fluctuated in response to changing water-table conditions. Potential sources include past disposal of sodium dichromate near H Reactor, disposal to the inactive 107-H liquid waste disposal trench, and chromium in acid waste stored in the former 183-H basins (Peterson and Connelly 1992). Upgradient sources include waste sites in the 100-D Area. Chromium was also found at levels above the drinking water standard in one well monitoring the deeper part of the unconfined aquifer. Filtered samples from this well, located near the former 183-H basins, contained 160 µg/L of chromium in 2000. Chromium levels in this well have been decreasing in recent years.

Chromium in the 100-K Area occurs in groundwater at levels greater than the drinking water standard in three areas (Figure 7.1.27). Two localized areas of chromium contamination occur near the KW Reactor and the water treatment basins southeast of the KE Reactor. The maximum concentration near the KW Reactor in 2000 was 463 µg/L. Trends show that chromium concentrations decreased in 2000 near the KW Reactor after showing increases the previous two years. This decline is suspected to be the result of dilution caused by infiltration of surface water sources, such as precipitation and leaking utility lines. One potential source of the chromium plume near the KW Reactor is the railcar transfer station and storage tanks southeast of the 183-KW water treatment plant. The other small chromium plume occurs near the 183-KE water treatment basins.

The most likely sources of this chromium are sodium dichromate storage tanks or the railcar transfer station near the area. The maximum chromium concentration in this plume in 2000 was 543 µg/L adjacent to the treatment basins.

A much wider area of chromium contamination is found in vicinity of the former 116-K-2 liquid waste disposal trench to the northeast. The maximum concentration in this area was 164 µg/L in 2000.

In the 100-N Area, chromium contamination is not widespread in groundwater. However, filtered samples in one well that monitors a locally confined unit within the Ringold Formation have consistently shown concentrations at steady levels greater than the drinking water standard. This well is northwest of the 1301-N Liquid Waste Disposal Facility. The maximum chromium concentration in 2000 was 172 µg/L. Chromium was disposed to the 1301-N Liquid Waste Disposal Facility until the early 1970s (DOE/RL-96-39).

Chromium in the 200 Areas. Chromium at concentrations greater than the drinking water standard in the 200-East Area was found in one well on the southern boundary of A and AX tank farms. The maximum concentration detected in samples collected from this well was 3,250 µg/L. A special study was conducted in 2000 to investigate the high metal (chromium, nickel, and manganese) concentrations at this well. The study indicated that the elevated metal concentrations historically found at this well are related to corrosion of the well screen.

Chromium contamination has been found in small areas in the 200-West Area. Areas where concentrations exceeded the drinking water standard in 2000 include the T, TX, and TY tank farms. Filtered samples from a well east of TX and TY tank farms showed a maximum concentration of 542 µg/L, the highest filtered chromium concentration in the 200-West Area. The highest concentration found at the T tank farm was 257 µg/L. Chromium concentrations have generally been
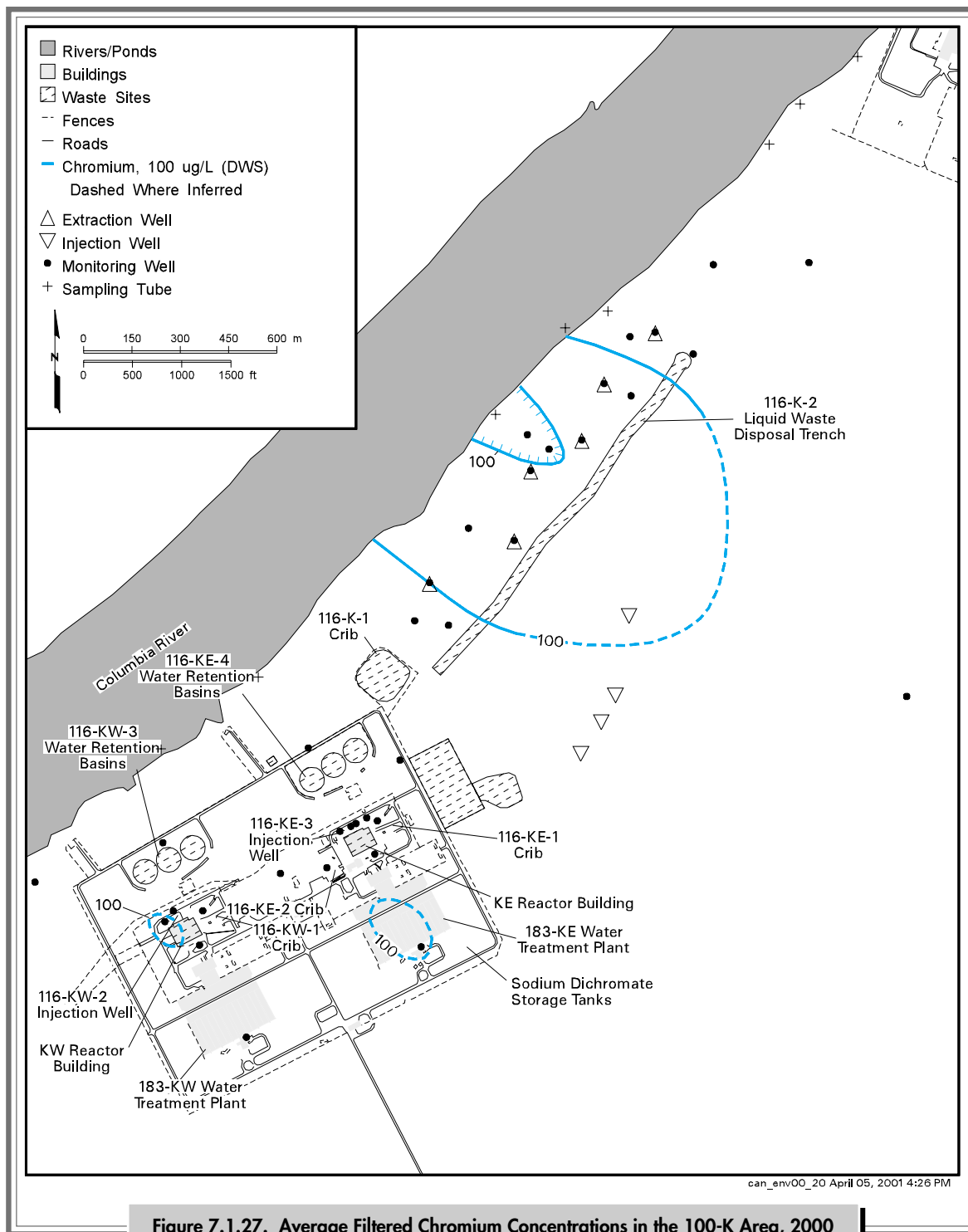
Legend:
- Rivers/Ponds
- Buildings
- Waste Sites
- Fences
- Roads
- Chromium, 100 ug/L (DWS) Dashed Where Inferred
- △ Extraction Well
- ▽ Injection Well
- ● Monitoring Well
- + Sampling Tube

0   150   300   450   600 m
0   500   1000   1500 ft

116-K-2
Liquid Waste
Disposal Trench

100

116-K-1
Crib

Columbia River

116-KE-4
Water Retention
Basins

116-KW-3
Water Retention
Basins

100

116-KE-3
Injection
Well

116-KE-1
Crib

116-KE-2 Crib

116-KW-1
Crib

KE Reactor Building

183-KE Water
Treatment Plant

Sodium Dichromate
Storage Tanks

116-KW-2
Injection Well

KW Reactor
Building

183-KW Water
Treatment Plant

100

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Figure 7.1.27. Average Filtered Chromium Concentrations in the 100-K Area, 2000

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increasing in these areas. Chromium concentrations previously elevated above the drinking water standard near the former 216-S-10 pond declined to levels below the drinking water standard in 2000.

Chromium in Other Areas. Filtered chromium concentrations above the drinking water standard frequently occur south of the 200-East Area. The maximum concentration detected in filtered samples in this area in 2000 was 201 μg/L. The extent of chromium contamination in this area is poorly defined, and the source has not been determined.

Carbon Tetrachloride. Carbon tetrachloride contamination occurs above the 5-μg/L drinking water standard in much of the 200-West Area and represents one of the most significant contaminant plumes at the Hanford Site (Figure 7.1.28). The maximum detected concentration was 7,100 μg/L near the Plutonium Finishing Plant in the 200-West Area. The plume, which covers an area that is more than 11 square kilometers (4 square miles), extends past the 200-West Area boundary into the 600 Area.

The bulk of the contamination is believed to be from waste disposal operations associated with the Plutonium Finishing Plant in the west-central part of the 200-West Area. Major sources identified in this area include the 216-Z-9 trench, the 216-Z-1A drain/tile field, and the 216-Z-18 crib. Carbon tetrachloride was used as the carrier solvent for tributyl phosphate in the final purification of plutonium. Carbon tetrachloride was also used in the same facility as a non-flammable thinning agent while machining plutonium. A minor source of carbon tetrachloride is a former waste disposal crib near T Plant. Carbon tetrachloride is immiscible in water but exhibits a relatively high solubility (805,000 μg/L at 20°C [68°F]). Carbon tetrachloride has been found to have a relatively high degree of mobility in groundwater. Mobilization above the water table can also occur through vapor transport.

Wells in vicinity of the Plutonium Finishing Plant showed the highest concentrations in the plume, with levels exceeding the drinking water standard by more than two orders of magnitude. The maximum concentration was 7,100 μg/L near one pump-and-treat extraction well just north of the plant. Pump-and-treat operations, which began in 1994, have influenced the distribution of carbon tetrachloride. In the center of the plume, the area within the 4,000-μg/L contour has increased in size because of the effects of pumping from the extraction wells downgradient of this area. The plume center moved to the north and east toward the extraction wells in recent years, as evidenced by increased concentrations in several extraction and monitoring wells (BHI-01311). Concentrations increased in the two northern extraction wells during 2000. The extraction wells are located north and east of the Plutonium Finishing Plant. Carbon tetrachloride concentrations were below the minimum detection limit in vicinity of the injection wells southwest of the plant during 2000. Concentrations have declined because of injection of the treated water. The pump-and-treat system removed 1,318 kilograms (2,906 pounds) of carbon tetrachloride in 2000.

The carbon tetrachloride plume is divided into two major lobes, one in the northern half and one in the southern half of the 200-West Area. In the northern lobe, an area of increasing carbon tetrachloride concentrations has moved slowly beyond the northeastern 200-West Area boundary since 1997. In the southern lobe, carbon tetrachloride concentrations continue to increase near the S-SX tank farm to levels averaging 130 μg/L during 2000.

The extent of carbon tetrachloride contamination in deeper parts of the aquifer is uncertain because of the limited concentration data from depths below the water table. The limited amount of data indicates that the concentrations are highest at the top of the aquifer and decline with depth at most locations within the plume. Carbon tetrachloride contamination has been detected to depths greater than 60 meters (197 feet) below the water
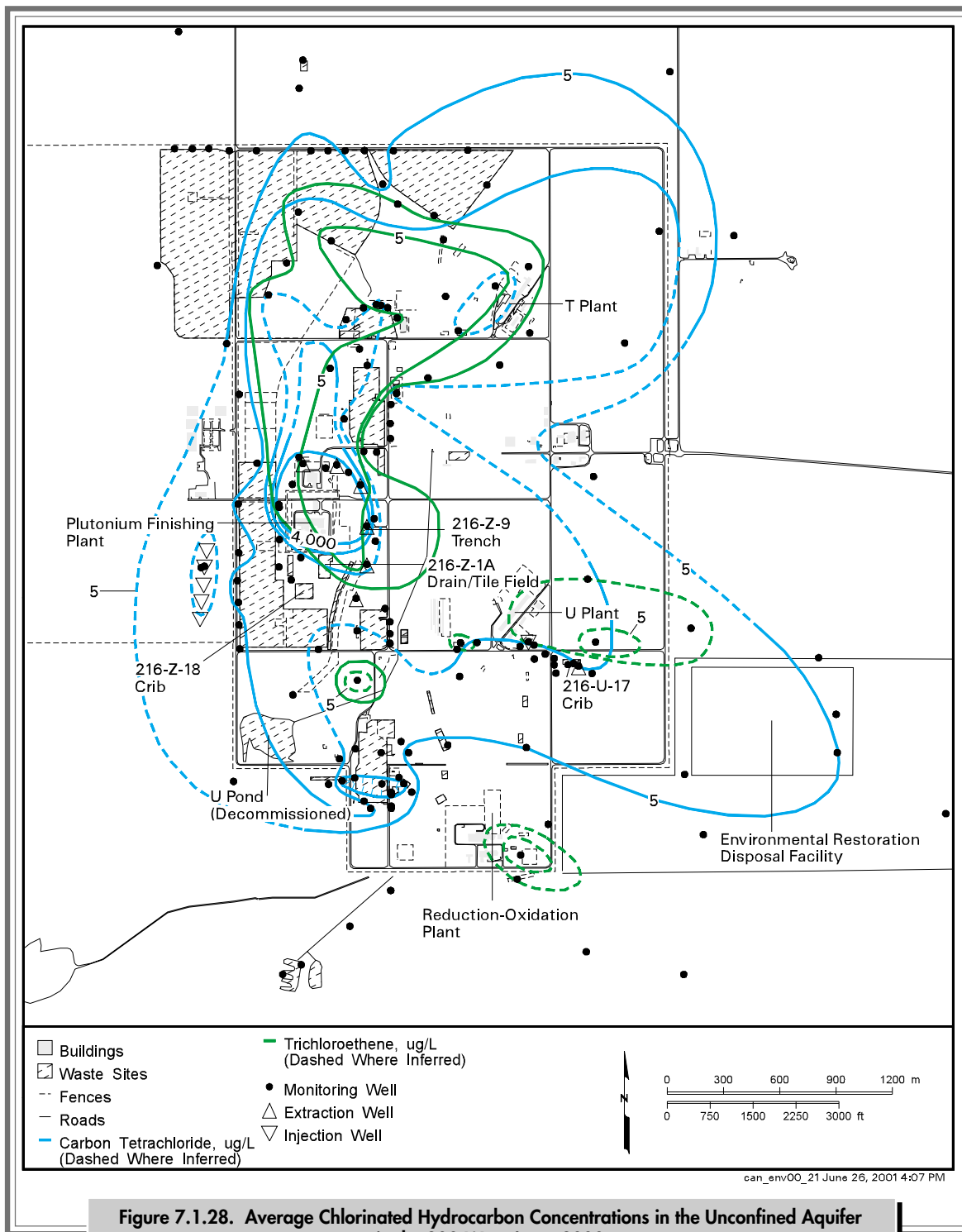
Figure 7.1.28. Average Chlorinated Hydrocarbon Concentrations in the Unconfined Aquifer in the 200-West Area, 2000

Legend:
- Buildings
- Waste Sites
- Fences
- Roads
- Carbon Tetrachloride, ug/L (Dashed Where Inferred)
- Trichloroethene, ug/L (Dashed Where Inferred)
- Monitoring Well
- Extraction Well
- Injection Well

Map labels:
- T Plant
- Plutonium Finishing Plant
- 216-Z-9 Trench
- 216-Z-1A Drain/Tile Field
- U Plant
- 216-Z-18 Crib
- 216-U-17 Crib
- U Pond (Decommissioned)
- Environmental Restoration Disposal Facility
- Reduction-Oxidation Plant

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table. A detailed summary of available data indicates that carbon tetrachloride concentrations range up to 3,789 μg/L in the middle part of the unconfined aquifer (BHI-01311). In the lower part of the unconfined aquifer, carbon tetrachloride concentrations range up to 2,651 μg/L. These data represent samples collected between 1991 and 1999.

Changes in groundwater flow since decommissioning U Pond may influence the plume configuration and the concentrations at particular locations. Another potential influence is the continued spreading of carbon tetrachloride above the water table, in either the liquid or the vapor phase. Free-phase, liquid, carbon tetrachloride above and possibly below the water table provides a continuing source of contamination. Therefore, lateral expansion of the carbon tetrachloride plume is expected to continue.

Chloroform. A chloroform plume appears to be associated with, but not exactly coincident with, the carbon tetrachloride plume in the 200-West Area. The highest chloroform concentrations were measured in vicinity of the Plutonium Finishing Plant, where the maximum level was 130 μg/L. The drinking water standard for chloroform is 100 μg/L (total trihalomethanes). The origin of chloroform is suspected to be a degradation product of carbon tetrachloride or an anaerobic degradation product associated with septic drain fields.

Trichloroethene. A commonly used organic solvent, trichloroethene has a drinking water standard of 5 μg/L. In 2000, trichloroethene was detected at levels greater than the drinking water standard in several wells in the 100, 200, 300, and 600 Areas. The most widespread area of contamination occurred in the 200-West Area.

Trichloroethene in the 100 Areas. Trichloroethene was detected at levels greater than the drinking water standard in the southwestern corner of the 100-F Area and in the adjacent 600 Area. Trichloroethene concentrations in this area show slowly declining trends. The maximum concentration detected in this area was 16 μg/L in both the 100-F and adjacent 600 Areas. No specific sources of this contamination have been identified.

In the 100-K Area, a localized area of trichloroethene contamination occurs near the KW Reactor complex. This area of contamination resulted from the past disposal/spillage of organic solvents. One well downgradient of the KW Reactor showed a maximum trichloroethene concentration above the drinking water standard at a level of 11 μg/L. Trichloroethene concentrations appear to be decreasing with time.

Trichloroethene in the 200 Areas. Trichloroethene was detected at levels greater than the drinking water standard in several parts of the 200-West Area (see Figure 7.1.28). The most significant area extends from the Plutonium Finishing Plant northeast to an area west of T Plant. The source of the contamination is presumably past disposal in these plant areas. The highest concentration was 31 μg/L northeast of the Plutonium Finishing Plant near the northern extraction wells for the carbon tetrachloride 200-ZP-1 pump-and-treat system. A smaller, isolated area of contamination occurs downgradient of the U Plant cribs, where the maximum concentration was 15 μg/L. Another localized area of trichloroethene contamination occurs east of the Reduction-Oxidation Plant in the southern part of the 200-West Area. The maximum concentration in this area in 2000 was 9 μg/L.

Trichloroethene in the 300 and 600 Areas. A localized plume of trichloroethene occurs in the 300 Area near the 316-5 process trenches. Trichloroethene was detected at a concentration above the drinking water standard in one well downgradient of the process trenches. The maximum concentration in 2000 was 5.3 μg/L.

Trichloroethene was found at a level above the drinking water standard in one well in vicinity of the inactive Horn Rapids landfill in the southern

part of the site (Richland North Area). This contamination, which is degrading naturally, forms an elongated plume that extends from an area just south of the landfill to near the southwestern corner of the 300 Area and has an origin off the Hanford Site. The maximum contamination detected in this plume in 2000 was 5.1 µg/L on the northeastern side of the landfill.

cis-1,2-Dichloroethene. Concentrations of cis-1,2-dichloroethene remain elevated in one well near the former process trenches and ponds in the 300 Area. This well is completed in the deeper part of the unconfined aquifer and is the only well on the site where this constituent is found at levels above the 70-µg/L drinking water standard. In 2000, a maximum of 170 µg/L was detected in this well. The source of the cis-1,2-dichloroethene is the 316-5 process trenches.

Cyanide. Waste fractionation activities performed in the late 1950s used large quantities of sodium and nickel ferrocyanide to recover cesium-137. Large volumes of aqueous supernatant waste containing excess ferrocyanide were disposed to the ground in both the northern and southern portions of the 200-East Area. Smaller quantities were also disposed to former cribs in the 200-West Area. Procedures used to analyze for cyanide do not distinguish between ferrocyanide and free cyanide. Cyanide results reported here are, thus, normally assumed to be residual ferrocyanide associated with the discharges from the waste fractionation activities performed more than 30 years ago. A chemical speciation study performed in 1988 indicated that approximately one-third of the cyanide in groundwater is present as free cyanide and the rest may be present as ferrocyanide (Section 4.1 in PNL-6886 and Section 3.2.2 in PNL-7120). The drinking water standard for cyanide is 200 µg/L.

The highest cyanide levels were detected in samples collected from wells in the northwestern part of the 200-East Area and in the 600 Area north of the 200-East Area. Samples collected from two wells near the inactive BY cribs showed concentrations above the drinking water standard in 2000. The maximum concentration near the cribs was 411 µg/L. Cyanide levels near the cribs have generally increased along with associated technetium-99 and cobalt-60. Although cobalt-60 is normally immobile in the subsurface, it appears to be chemically complexed by cyanide or ferrocyanide. The complexed chemical species is more soluble and more mobile in groundwater.

Fluoride. At this time, fluoride has a primary drinking water standard of 4 mg/L and a secondary standard of 2 mg/L. Secondary standards are based primarily on aesthetic rather than health considerations. Fluoride was detected above the primary drinking water standard in three wells monitoring T tank farm in the 200-West Area in 2000. The maximum fluoride concentration was 9.8 mg/L near the 216-T-7 crib. A few other wells near the T tank farm showed concentrations above the secondary standard. Aluminum fluoride nitrate used in past 200-West Area processes is the probable source of the fluoride contamination.

7.1.6.3 Radiological and Chemical Monitoring Results for the Upper Basalt-Confined Aquifer

The purpose in monitoring groundwater in the upper basalt-confined aquifer is to determine the potential for hazardous or radiological contamination within this aquifer. Monitoring the upper basalt-confined aquifer is important because of the potential for downward migration of contaminants from the overlying unconfined aquifer. Contaminants that reach the upper basalt-confined aquifer have the potential to migrate off the Hanford Site. The upper basalt-confined aquifer is also monitored to assess the potential migration of contaminants onto the Hanford Site from offsite sources.

The upper basalt-confined aquifer is monitored by ~40 wells that are sampled annually to triennially. Most of these wells are located near the 200 Areas in the central part of the Hanford Site (see Figure 7.1.9). During 2000, nine upper basalt-confined aquifer wells were sampled for chemical and radiological constituents.

During 2000, most of the wells that represent the upper basalt-confined aquifer were sampled for tritium, iodine-129, and nitrate. These constituents are the most widespread in the overlying unconfined aquifer, are most mobile in groundwater, and provide an early warning of potential contamination in the upper basalt-confined aquifer. The distribution of sample results for these and other selected constituents are shown in Figure 7.1.29. Constituent concentrations for all samples collected from the upper basalt-confined aquifer were less than their respective drinking water standard during 2000. The highest tritium concentration found in the upper basalt-confined aquifer in 2000 was 5,770 pCi/L beneath B Pond. Since 1996, tritium concentrations have declined steadily at this location. Tritium at this location is believed to have originated from downward migration from the overlying, unconfined aquifer. Iodine-129 was not detected in samples collected from wells that represent the upper basalt-confined aquifer. In most of the wells sampled for nitrate, concentrations in the upper basalt-confined aquifer increased during 2000. The highest nitrate concentration detected, 11 mg/L, was found just north of the 200-East Area. The distribution of contaminants in the upper basalt-confined aquifer is discussed more thoroughly in the fiscal year 2000 annual groundwater report (PNNL-13404).

Aquifers confined below the uppermost basalt layers are affected much less from Hanford Site contamination than the unconfined aquifer system within the overlying sediment. The minor contamination found in the basalt-confined aquifers may be attributed to several factors. These factors include areas where the confining layers of basalt have been eroded away, areas where past disposal of large amounts of water resulted in downward gradients, and areas where wells penetrating to the confined aquifers provided pathways for contaminant migration. These factors produced intercommunication between the aquifers, meaning they permitted the flow of groundwater from the unconfined aquifer to the underlying confined aquifer, thereby increasing the potential to spread contamination.

Intercommunication between the unconfined and basalt-confined aquifers in vicinity of the northern part of the 200-East Area has been identified previously in RHO-BWI-ST-5 and RHO-RE-ST-12 P. Several confined aquifer wells north and east of the 200-East Area that show evidence of intercommunication with the overlying unconfined aquifer were identified in PNL-10817. Intercommunication between the unconfined and confined aquifers in this area has been attributed to erosion of the upper Saddle Mountains Basalt and a downward vertical gradient that resulted from groundwater mounding associated with past waste disposal. Since the groundwater mound diminished, the downward vertical gradient has decreased in recent years and was negligible in 2000.

Groundwater data indicate that a downward hydraulic gradient from the unconfined to the confined aquifers also occurs in the western portion of the Hanford Site and in regions north and east of the Columbia River. However, groundwater chemical and radiological data from most confined aquifer wells in these other areas do not exhibit evidence of contamination. Exceptions are wells that were previously open to both the unconfined and confined aquifers, thus providing conduits for the downward transport of contamination.
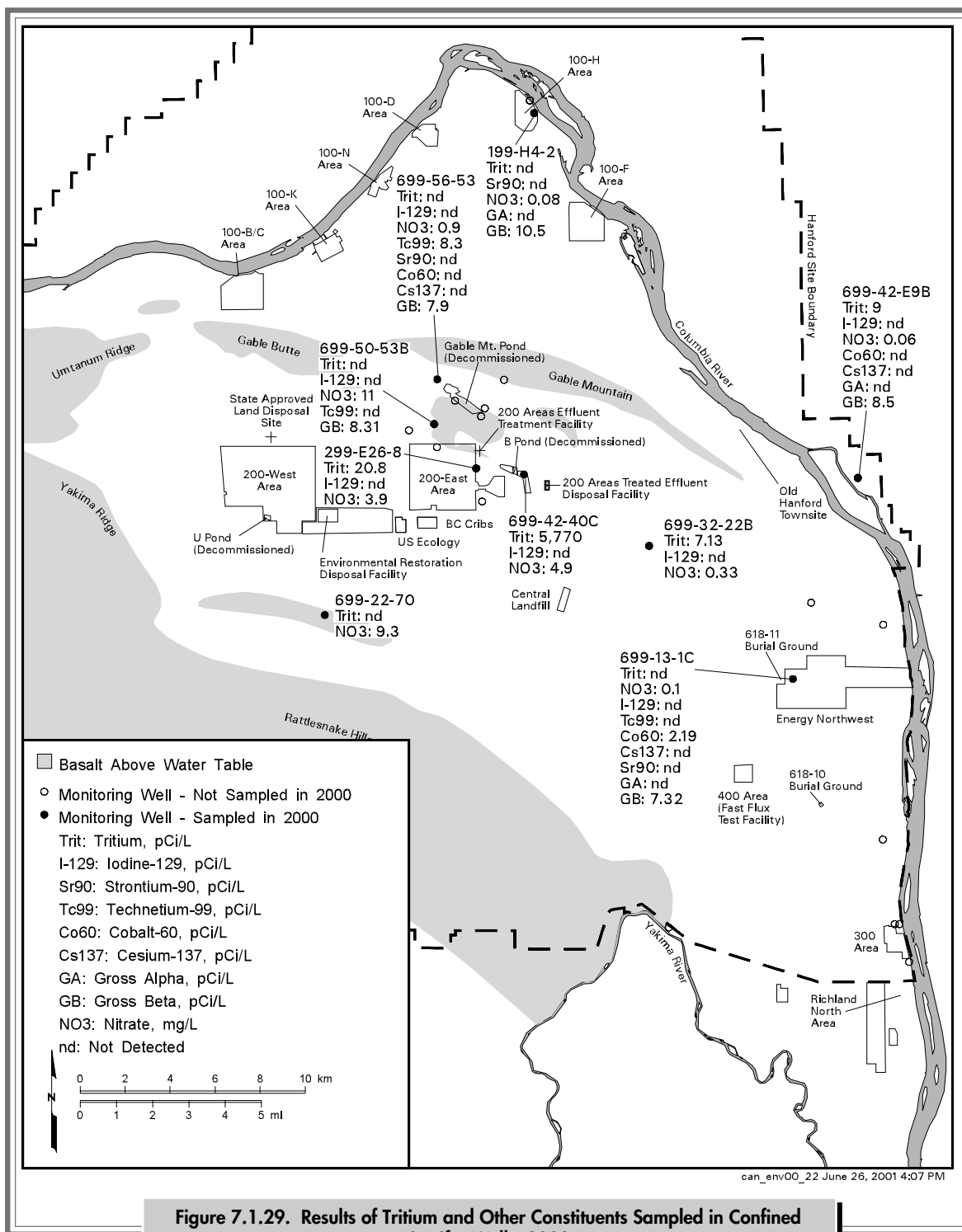
Figure 7.1.29. Results of Tritium and Other Constituents Sampled in Confined Aquifer Wells, 2000

Map labels and legend:

100-H Area
100-D Area
100-N Area
100-K Area
100-B/C Area
100-F Area

199-H4-2
Trit: nd
Sr90: nd
NO3: 0.08
GA: nd
GB: 10.5

699-56-53
Trit: nd
I-129: nd
NO3: 0.9
Tc99: 8.3
Sr90: nd
Co60: nd
Cs137: nd
GB: 7.9

699-42-E9B
Trit: 9
I-129: nd
NO3: 0.06
Co60: nd
Cs137: nd
GA: nd
GB: 8.5

Hanford Site Boundary

Columbia River

Umtanum Ridge
Gable Butte
Gable Mountain
Gable Mt. Pond (Decommissioned)

699-50-53B
Trit: nd
I-129: nd
NO3: 11
Tc99: nd
GB: 8.31

State Approved Land Disposal Site

200 Areas Effluent Treatment Facility
B Pond (Decommissioned)

299-E26-8
Trit: 20.8
I-129: nd
NO3: 3.9

200-West Area
200-East Area

200 Areas Treated Effluent Disposal Facility

Old Hanford Townsite

Yakima Ridge

U Pond (Decommissioned)
Environmental Restoration Disposal Facility
US Ecology
BC Cribs

699-42-40C
Trit: 5,770
I-129: nd
NO3: 4.9

699-32-22B
Trit: 7.13
I-129: nd
NO3: 0.33

699-22-70
Trit: nd
NO3: 9.3

Central Landfill

618-11 Burial Ground

699-13-1C
Trit: nd
NO3: 0.1
I-129: nd
Tc99: nd
Co60: 2.19
Cs137: nd
Sr90: nd
GA: nd
GB: 7.32

Energy Northwest

Rattlesnake Hills

400 Area (Fast Flux Test Facility)
618-10 Burial Ground

Yakima River

300 Area

Richland North Area

Legend:
Basalt Above Water Table
○ Monitoring Well - Not Sampled in 2000
● Monitoring Well - Sampled in 2000
Trit: Tritium, pCi/L
I-129: Iodine-129, pCi/L
Sr90: Strontium-90, pCi/L
Tc99: Technetium-99, pCi/L
Co60: Cobalt-60, pCi/L
Cs137: Cesium-137, pCi/L
GA: Gross Alpha, pCi/L
GB: Gross Beta, pCi/L
NO3: Nitrate, mg/L
nd: Not Detected

0 2 4 6 8 10 km
0 1 2 3 4 5 mi

N

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7.1.7 RCRA Summary

More than 60 treatment, storage, and disposal units are recognized under the RCRA permit for the Hanford Site. Of these, 25 required groundwater monitoring during 2000. Locations of these groundwater monitoring sites were given in Figure 7.1.10. This section provides a summary of groundwater monitoring activities and results for these sites during calendar year 2000. Additional information, including complete listings of radioactive and chemical constituents measured in monitoring wells from October 1999 through September 2000, is available in PNNL-13404.

RCRA groundwater monitoring is conducted under one of three phases: 1) indicator parameter/detection, 2) groundwater quality assessment/compliance, or 3) corrective action. Initially, a detection program is developed to monitor the impact of facility operations on groundwater. During the indicator parameter/detection phase, groundwater parameters established for the particular site are measured in wells upgradient and downgradient from the site. Statistical tests are applied to the monitoring results to calculate "critical mean" values for each monitoring parameter. These values represent the background water quality for the site. Subsequent monitoring data are compared to the critical mean values to determine if there has been a statistically significant change in the concentrations of key indicator parameters or dangerous waste constituents in the groundwater. The statistical methods used to calculate critical means and compare with monitoring data are described in Appendix B in PNNL-12086.

If a statistically significant change from the "critical mean" is observed, then a groundwater quality assessment/compliance phase of monitoring and investigation is initiated. During this phase, groundwater monitoring is designed to determine if groundwater protection standards have been exceeded. If the source of the contaminants is determined to be the treatment, storage, and disposal unit and concentrations exceed maximum contaminant levels defined in the monitoring plan or permit, then the Washington State Department of Ecology may require corrective action to reduce the contaminant hazards to the public and environment. Groundwater monitoring during the corrective action phase is designed to assess the effectiveness of the corrective action. Table 2.2.2 in Section 2.2 lists the phase pertaining to each of the RCRA groundwater monitoring projects at the end of 2000.

7.1.7.1 100 Areas Facilities

183-H Solar Evaporation Basins. This facility consisted of four separate concrete basins surrounded by an earthen berm. The basins have been demolished and contaminated soil removed from the site. Between 1973 and 1985, the basins were used to store liquid waste, primarily from nuclear fuel fabrication activities conducted in the 300 Area. Solar evaporation reduced the volume of liquid waste. The waste was predominantly acid etch solution that had been neutralized with sodium hydroxide before being discharged into the basins. The solution included chromic, hydrofluoric, nitric, and sulfuric acids and also contained various metallic and radioactive constituents. Groundwater in the vicinity of these basins is characterized by elevated levels of chromium, nitrate, technetium-99, and uranium. All of these constituents were present in waste discharged to the basins when they were in use.

This site continued to be monitored under a final status corrective-action program during 2000 (WAC 173-303-645). Groundwater remediation is integrated with the 100-HR-3 operable unit, where remediation for chromium is under way. While the pump-and-treat system is operating, RCRA monitoring consists of annual sampling of four wells for chromium, fluoride, nitrate, technetium-99, and

uranium. The wells were sampled in November 2000. Contaminant concentrations fluctuate in response to changes in river stage, and continued to exceed concentration limits in one or more wells.

1301-N and 1325-N Liquid Waste Disposal Facilities. These facilities contaminated groundwater with radionuclides, most notably strontium-90 and tritium, as discussed in Section 7.1.6.1. A pump-and-treat system is active as a CERCLA interim action to reduce the amount of strontium-90 flowing into the Columbia River at the 100-N Area. RCRA monitoring focuses on the hazardous (non-radioactive) constituents discharged to the facilities.

The 1301-N facility was the primary liquid waste disposal site for N Reactor from 1963 until 1985. Discharges were primarily radioactive fission and activation products. Minor amounts of dangerous waste and other constituents may also have been discharged, including ammonium hydroxide, cadmium, diethylthiourea, lead, morpholine, phosphoric acid, and sodium dichromate. The facility consists of a concrete basin with an unlined, zigzagging extension trench covered with concrete panels.

The 1325-N facility was constructed in 1983 and also received effluent from N Reactor. In 1985, discharge to 1301-N ceased, and all effluent was sent to 1325-N. All discharge to 1325-N ceased in late 1991. The facility consists of a concrete basin with an unlined extension trench, covered with concrete panels. Beginning in July 2000, contaminated sediment and concrete from the trench was excavated and disposed in the Environmental Restoration Disposal Facility near the 200 West Area. Remediation of the trench and crib continues in 2001.

During 2000, upgradient and downgradient wells at the 1301-N and 1325-N facilities were sampled twice. At the 1301-N facility, total organic carbon in downgradient well 199-N-3 exceeded the critical mean value in September 2000. DOE notified the Washington State Department of Ecology of a previous exceedance in this well in February 1999. Because no organic constituents of

concern have been identified in 1301-N waste or sediment, the contamination is assumed to come from another source, and the site remains in indicator evaluation status.

Average specific conductance values in downgradient well 199-N-41 at the 1325-N facility continued to exceed the critical mean value in 2000. DOE notified the Washington State Department of Ecology of a previous exceedance and submitted an assessment report that concluded the exceedance did not indicate contamination from the facility and originated at an upgradient source.

Of the dangerous waste constituents or byproduct discharged to these facilities, only nitrate exceeded the maximum contaminant level, and the sources are unclear (see Section 2.4.3 of PNNL-13116). The 1301-N and 1325-N facilities have contaminated the groundwater with tritium and strontium-90, but radionuclides are not monitored as part of the RCRA program at these facilities.

The closure plan for these facilities was revised and incorporated into a modification of the Hanford Site RCRA Permit (Ecology 1994) in 1999. Remedial actions will be integrated with the 100-NR-1 and 100-NR-2 operable units. The closure plan (DOE/RL-96-39) states that RCRA monitoring during and after closure activities will continue, according to the existing interim status monitoring plan (WHC-SD-EN-AP-038).

1324-N and 1324-NA Ponds. The 1324-N pond was a treatment facility that was in service from May 1986 to November 1988. This facility is a double-lined pond that was used for neutralizing high- and low-pH waste from a demineralization plant. The 1324-NA pond is unlined and was used for neutralizing waste from August 1977 to May 1986 and for disposing of treated waste from May 1986 to August 1990. The effluent to both facilities contained sulfuric acid and sodium hydroxide, and the pH was occasionally high or low enough to classify the effluent as a dangerous waste.

Specific conductance in wells downgradient of the 1324-N/NA site continued to exceed the critical mean value in 2000. A previous groundwater quality assessment indicated that the high specific conductance is caused by the non-hazardous constituents sulfate and sodium (WHC-SD-EN-EV-003). Because an assessment has been completed already and non-hazardous constituents caused the high conductance, no further action was needed.

The closure plan for these facilities was revised and incorporated into a modification of the Hanford Site RCRA Permit (Ecology 1994) in 1999. Remedial action will be integrated with the 100-NR-1 and 100-NR-2 operable units. The closure plan (DOE/RL-96-39) states that RCRA monitoring during and after closure activities will continue, according to the existing interim status monitoring plan (WHC-SD-EN-AP-038).

7.1.7.2 200 Areas Single-Shell Tank Farms

Single-shell tanks are located in the A, AX, B, BX, BY, C, S, SX, T, TX, TY, and U tank farms, which have been designated as parts of RCRA Waste Management Areas A-AX, B-BX-BY, C, S-SX, T, TX-TY, and U. Waste Management Areas A-AX, B-BX-BY, and C are located in the 200-East Area; Waste Management Areas S-SX, T, TX-TY, and U are in the 200-West Area. Each waste management area includes tanks and associated ancillary systems (e.g., pipelines). The single-shell tanks store a mixture of dangerous chemical and radioactive waste generated by reprocessing fuel irradiated in Hanford Site reactors. The single-shell tanks received mixtures of organic and inorganic liquids that contain radionuclides, solvents, and metals that were originally discharged to the tanks as alkaline slurries. Subsequent waste management operations combined waste streams from different processes. In many tanks, waste have been concentrated by removing water through evaporation.

Waste Management Area A-AX. This RCRA site continued to be monitored under an interim status indicator evaluation program in 2000. Wells were sampled twice for indicator and site-specific parameters. Indicator parameter data from upgradient wells were statistically evaluated, and values from downgradient wells were compared to those established from the upgradient wells. The indicator parameters (specific conductance, total organic carbon, pH, and total organic halides) did not exceed critical mean values during 2000.

The well network for this site may not be adequate for RCRA monitoring. It was designed for groundwater flow toward the southwest, but recent studies have suggested flow may be eastward. In addition, the aquifer is less than 5 meters (16 feet) thick and the water table is declining so wells may go dry. However, the rate of decline decreased in 2000, and if this rate continues, the RCRA compliant wells in the monitoring network will remain usable for at least 15 to 20 years.

Waste Management Area B-BX-BY. RCRA assessment monitoring continued at this waste management area in 2000. Exceedances of the critical mean value for specific conductance in February 1996 at well 299-E33-32 initiated assessment monitoring. Results of the initial assessment investigation indicated that tank waste from this waste management area had reached the groundwater (PNNL-11826). Monitoring in 2000 continued to indicate the presence of three distinct plumes in the area, based on groundwater chemistry, spatial relationships, historic plume movement, and chemical ratios. Groundwater beneath the BY cribs, north of the waste management area, has the highest level of technetium-99 in the vicinity. This contamination is attributed to discharges to the cribs in the 1950s and forms an extensive plume that now is moving to the south, affecting the groundwater under Waste Management Area B-BX-BY. The highest concentration of nitrate is detected under the 216-B-8 crib, located

east of the waste management area. This contamination is believed to be mostly associated with discharges to the crib in the late 1940s. A local depression in the basalt bedrock exists in this area, and the contamination may be sitting in a partially stagnant pool. Technetium-99, nitrate, and nitrite have recently increased in wells near the BY tank farm. This contamination may have originated from past leaks within Waste Management Area B-BX-BY.

Fiscal year 2000 studies helped refine the interpretation of the direction of groundwater flow in and near Waste Management Area B-BX-BY. Although the data showed local variability, the overall direction of flow appears to be toward the south beneath the waste management area. In the past, when the water table beneath the 200 Areas was higher, groundwater flowed to the northwest. Three new monitoring wells will be installed in 2001.

Waste Management Area C. This RCRA site continued to be monitored under an interim status indicator evaluation program in 2000. Wells were sampled monthly in 2000 to assess the potential impact of removal and sluicing of tank contents (no impact was detected). In addition, the required detection sampling was conducted twice for indicator and site-specific parameters. Indicator parameter data from upgradient wells were statistically evaluated. Values from downgradient wells were compared to values established from the upgradient wells. The indicator parameters (specific conductance, total organic carbon, pH, and total organic halides) did not exceed critical mean values during 2000.

Currently, the well network for this site appears to comply only marginally with the required placement of groundwater monitoring wells because of changes and uncertainty in the direction of flow.

Waste Management Area S-SX. This RCRA site continued to be monitored under an interim status assessment program during 2000.

DOE initiated the assessment program in response to a directive from the Washington State Department of Ecology in 1996. The directive cited anomalous trends in technetium-99 and high specific conductance as primary reasons for the assessment. A report on the results of the assessment (PNNL-11810) concluded that sources within the waste management area contributed to groundwater contamination.

Assessment activities continued in 2000 with installation of new wells, hydrologic and tracer testing, and additional sampling and analysis to evaluate the rate of contaminant movement and the extent and concentrations of contaminants. The most significant finding during the year was the persistent and gradually increasing trend in technetium-99 in a new well in the southwestern corner of the SX tank farm. Technetium-99 concentrations increased from 39,000 pCi/L on October 1999 to 72,300 pCi/L in December 2000. The contamination is attributed to previous tank waste leaks to the soil in that area. Circumstantial evidence suggests leakage from a nearby water line may be a recent driving force for transport of vadose zone contamination to groundwater. Water lines in this area are being isolated during 2001 as one interim corrective measure.

Although the occurrence of technetium-99 at the SX tank farm is the highest concentration detected in groundwater at the Hanford Site, the contaminant plume appears to be localized and moving very slowly (<50 meters per year) to the east-southeast. Other tank waste constituents of concern (strontium-90, cesium-137, neptunium-237, plutonium-239/240, americium-241 and iodine-129) were analyzed in key network wells but all were below detection limits. Based on the groundwater data collected to date, only the more mobile tank waste constituents (e.g., technetium-99, nitrate, hexavalent chromium, tritium) have reached groundwater beneath Waste Management Area S-SX.

Waste Management Area T. This RCRA site continued to be monitored under an interim status assessment program during 2000. Waste Management Areas T and TX-TY began assessment monitoring in November 1992 because of high specific conductance in downgradient wells. Assessment findings (PNNL-11809) indicated that contaminants in well 299-W10-15 are a result of sources outside the waste management area. There is strong evidence, however, that contaminants observed in well 299-W11-27, which include chromium, cobalt-60, nitrate, technetium-99, and tritium, are a result of sources within the waste management area, so assessment work has continued. The plume detected in well 299-W11-27 has reached well 299-W11-23, located to the east of 299-W11-27, apparently as a result of changed groundwater flow direction at Waste Management Area T.

Assessment activities at Waste Management Area T continued in 2000 with the addition of new wells, hydrologic testing, and sampling and analysis to aid in evaluation of the rate of contaminant transport, and the concentration and extent of contamination. Groundwater flow direction maintained a fairly constant direction, slightly north of east, during 2000. Relatively high concentrations of nitrate, chromium, and fluoride have been reported in a number of wells as a result of an upgradient contaminant plume moving across the area. Values of nitrate exceeding 1,000 mg/L have been detected in several wells. Samples collected during drilling near the northeastern corner of the waste management area, coupled with chemical data from an existing well, indicate that the top portion of the aquifer is relatively impermeable and contains a high-technetium plume. Deeper portions of the aquifer are more permeable and groundwater is characterized by high nitrate, similar to the upgradient plume.

The water table beneath Waste Management Area T continued to decline in 2000. Four new downgradient wells were installed to replace dry wells and to account for changes in the direction of groundwater flow.

Waste Management Area TX-TY. This RCRA unit also continued to be monitored under an interim status assessment program during 2000. Waste Management Area TX-TY began assessment monitoring in November 1991 because of high specific conductance in wells 299-W10-17 and 299-W14-12. The exceedance in well 299-W14-12 was accompanied by elevated cobalt-60, iodine-129, technetium-99, and tritium. Assessment results (PNNL-11809) indicated that contaminants in well 299-W10-17 are a result of sources outside the waste management area. Assessment results for well 299-W14-12 indicate that the contamination is consistent with a source within the waste management area, though upgradient sources are also possible. Because there was no direct evidence for upgradient sources, assessment continues at the site.

Assessment activities continued in 2000 with the addition of new wells, hydrologic testing, and sampling and analysis to aid in evaluation of the rate of contaminant transport and the concentration and extent of contamination. A plume with high levels of technetium-99 and a separate plume with high concentrations of tritium and iodine-129 and low levels of technetium-99 continued to be detected in the central portion of the waste management area. Tritium concentrations reached 2.9 million pCi/L and iodine-129 reached 48 pCi/L in a downgradient well east of the waste management area. The most likely source for the tritium and iodine-129 plume is the 242-T evaporator, located between the TX and TY tank farms. Increases in technetium-99 concentrations were detected in wells south of the waste management area, indicating the possibility that contaminants are being drawn toward a groundwater pump-and-treat system. The operation of a pump-and-treat system in an area south of Waste Management Area TX-TY has changed the direction of groundwater flow over the past several years. Beneath the

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southern part of the waste management area, flow is primarily to the south, which may be causing tank-related contaminants to move southward. Five new monitoring wells were installed downgradient of Waste Management Area TX-TY in 2000 to account for the changing flow direction and to track the plume farther from the waste management area.

Waste Management Area U. This site was placed in assessment in late 1999 because of an exceedance in the indicator parameter specific conductance. It remains in assessment because of elevated concentrations of chromium, nitrate, and technetium-99. Concentrations of these constituents were below drinking water standards, but they were above upgradient concentrations and a plausible upgradient source could not be identified.

The direction of groundwater flow beneath Waste Management Area U has been strongly influenced by the 200-ZP-1 pump-and-treat operations to remove carbon tetrachloride, particularly in the northern portion of the waste management area. One upgradient well went dry in fiscal year 2000. There are plans to replace this well and to drill several downgradient wells to improve the efficiency of the monitoring network.

7.1.7.3 200 Areas Liquid Effluent Disposal Facilities

216-A-10, 216-A-36B, and 216-A-37-1 Cribs. These inactive cribs in the 200-East Area received liquid waste from the Plutonium-Uranium Extraction Plant and contributed to the widespread plumes of tritium, iodine-129, and nitrate described in Sections 7.1.6.1 and 7.1.6.2. The waste stream at the 216-A-10 crib was characteristically acidic and contained concentrated salts, hydrocarbon compounds, organic complexants, plutonium, uranium, and other radionuclides. The 216-A-36B crib received ammonia scrubber distillate from nuclear fuel decladding operations, in which zirconium cladding was removed from irradiated fuel by boiling in a solution of ammonium fluoride and ammonium nitrate. Other waste stream constituents included tritium, cobalt-60, strontium-90, ruthenium-106, iodine-129, cesium-137, and uranium. The 216-A-37-1 crib received process condensate from the 242-A evaporator. The process condensate contained radionuclides, spent halogenated and non-halogenated solvents, and ammonia. The radionuclides included cobalt-60, strontium-90, ruthenium-106, cesium-137, uranium, and plutonium.

The 216-A-10, 216-A-36B, and 216-A-37-1 cribs were monitored under a RCRA assessment program in 2000. The sites are monitored together under an assessment program because they have similar hydrogeology and waste constituents and appear to have contaminated groundwater. Combining these cribs into one RCRA groundwater monitoring area saves sampling and analysis costs because the number of near-field wells is reduced. Many of the far-field wells that formerly were sampled annually are now sampled every 3 years. These wells mainly track the extent and flow rate of the extensive iodine-129, nitrate, and tritium plumes that typically change very little in a 3-year period.

During 2000, iodine-129, nitrate, and tritium continued to exceed interim drinking water standards or maximum contaminant levels in large areas downgradient of the cribs. Strontium-90, a beta emitter, and gross beta exceed the interim drinking water standards only in well 299-E17-14, which is near the 216-A-36B crib.

216-A-29 Ditch. This is an inactive earthen ditch ~2 kilometers (1.2 mile) long in the 200-East Area that conveyed Plutonium-Uranium Extraction Plant chemical waste to the 216-B-3 pond from 1955 to 1986. The ditch received effluents that contained dangerous chemical and radioactive contaminants. Of primary concern for RCRA regulations were discharges of sodium hydroxide and sulfuric acid, which occurred daily as a result of ion-exchange regeneration at the Plutonium-Uranium Extraction Plant.

This RCRA unit continued to be monitored under an interim status indicator evaluation program in 2000 and did not have an adverse impact on groundwater. Indicator parameter data from upgradient wells were statistically evaluated, and values from downgradient wells were compared to values established from the upgradient wells. Average specific conductance values at downgradient wells 299-E25-35 and 299-E25-48 exceeded the critical mean value and were linked to increases in sulfate, nitrate, calcium, and sodium from upgradient sources. DOE informed the Washington State Department of Ecology of the exceedances. Because the ditch was not the cause, indicator evaluation monitoring continues.

216-B-3 Pond (B Pond). This former pond in the 200-East Area consisted of a main pond and three expansion ponds (216-B-3A, 216-B-3B, and 216-B-3C). The main pond began operating in 1945 and the expansions were built in the 1980s. In 1994, the main pond ceased operating, and the waste streams were rerouted to the 216-B-3C expansion pond and the 200 Areas Treated Effluent Disposal Facility. In 1994, the main pond was filled with clean soil, and the expansion ponds were clean-closed (i.e., deemed free of dangerous waste and no longer regulated under RCRA). In August 1997, waste streams received by the expansion pond were diverted to the 200 Areas Treated Effluent Disposal Facility, thus ending operation of the B Pond system. In the past, B Pond received liquid waste from B Plant and the Plutonium-Uranium Extraction Plant, consisting of chemical sewer waste, cooling water, and steam condensate. These waste streams contained aluminum nitrate, nitric acid, potassium hydroxide, sulfuric acid, tritium, and other acids. In its later years, B Pond received non-dangerous, non-radioactive effluent primarily from the Plutonium-Uranium Extraction Plant and B Plant.

In 2000, groundwater monitoring at B Pond continued under an interim status indicator evaluation program. Groundwater beneath the site apparently was affected by tritium and nitrate from past discharges to B Pond. However, all replicate averages for contamination indicator parameters were below critical mean values or limits of quantitation during 2000.

216-B-63 Trench. This 200 East Area trench received liquid effluent from the B Plant chemical sewer from March 1970 to February 1992. The liquid effluent consisted of a mixture of steam condensate and raw water. Past releases to the trench also included sulfuric acid and sodium hydroxide solutions. Radioactive soil was dredged from the trench in August 1970, but no records exist of radioactive waste disposal to the trench.

In 2000, RCRA monitoring continued to indicate that no dangerous non-radioactive constituents from the site have entered groundwater. The well network was sampled twice for the indicator parameters pH, specific conductance, total organic carbon, and total organic halides. All replicate averages for contamination indicator parameters were below critical mean values or limits of quantitation during 2000.

216-U-12 Crib. This crib in the 200-West Area received wastewater containing dangerous chemical waste and radionuclides from April 1960 until February 1988. It continued to be monitored under an interim status assessment program in 2000. Assessment monitoring began in 1993 because of high specific conductance in two downgradient wells. The crib will not receive additional effluent and is scheduled, according to provisions of the Hanford Site RCRA Permit (Ecology 1994), to be closed under RCRA final status regulations in 2005.

In 2000, network monitoring wells were sampled quarterly for constituents of interest. Based on the results of the assessment investigation (PNNL-11574), the site remains in interim status assessment monitoring because of continued elevated levels of nitrate and technetium-99. However, the objective of the assessment monitoring,

rather than delineating the existing plumes, is to 1) determine whether the flux of constituents into the groundwater is increasing, staying the same, or decreasing; 2) monitor the known constituents until a near-term interim corrective action is defined; and 3) monitor until a final status plan is implemented. Nitrate, which had a source at this crib, remained elevated above the 45-mg/L standard in downgradient wells in 2000. Nitrate and technetium-99 concentrations are decreasing in most of the wells.

Currently, the 216-U-12 crib is monitored by two downgradient wells. Declining water levels rendered the upgradient well dry in the past year; other downgradient wells went dry in 1999. The groundwater monitoring network requires upgrading to satisfy RCRA interim status monitoring requirements. The Washington State Department of Ecology and DOE annually negotiate installation of future monitoring wells under an Interim Milestone agreement (M-24).

216-S-10 Pond and Ditch. The facility consisted of an open, unlined ditch and an open, unlined percolation pond in the 200-West Area. The pond and ditch received radioactive and dangerous chemical waste from the Reduction-Oxidation Plant from 1951 until 1985, when the pond and the lower part of the ditch were decommissioned and backfilled. The upper part of the ditch continued to receive non-dangerous, unregulated wastewater from 1985 through 1991.

During 2000, this facility continued to be monitored semiannually under a RCRA interim status indicator evaluation program. Statistical evaluation of indicator parameter data from downgradient wells indicates that the site is not affecting groundwater quality.

Chromium, which was elevated above the 100-μg/L standard in the upgradient well since 1992, declined sharply in 2000, averaging less than 20 μg/L. Because the upgradient well is located adjacent to the 216-S-10 pond, it is unclear if the

elevated chromium was from an upgradient source or from past discharges to the pond.

Currently, the 216-S-10 pond and ditch are monitored by only one upgradient well and two shallow downgradient wells because other wells have gone dry. The groundwater monitoring network requires upgrading to satisfy RCRA interim status requirements. At the current rate of water table decline, the downgradient wells are expected to go dry in 2001 and 2002. The Washington State Department of Ecology and DOE annually negotiate installation of future monitoring wells under an Interim Milestone agreement (M-24).

7.1.7.4 200 Areas Low-Level Burial Grounds

The low-level burial grounds are divided into five low-level waste management areas in the 200 Areas (see Figure 7.1.10). However, Low-Level Waste Management Area 5 has not been monitored for groundwater since 1996 because the site never received waste. The remaining low-level waste management areas are in the indicator parameter phase of RCRA groundwater monitoring.

Low-Level Waste Management Area 1. This waste management area in the 200-East Area consists of the 218-E-10 burial ground. Disposal activities began in 1960 and continue today. Materials placed in this facility are primarily failed equipment and mixed industrial waste from the Plutonium-Uranium Extraction Plant, B Plant, and N Reactor.

Groundwater monitoring under interim status requirements continued at this RCRA site in 2000. Downgradient monitoring well 299-E33-34 continued to exceed the critical mean for specific conductance. This exceedance appears to be related to the nitrate plume and is not related to Low-Level Waste Management Area 1. DOE informed the Washington State Department of Ecology of a previous exceedance. Because no waste has been placed in the northern portion of this site and there is a

nitrate plume from an upgradient source, no further action is necessary.

Low-Level Waste Management Area 2. This waste management area in the 200-East Area includes all of the 218-E-12B burial ground, which has been in use since 1968. The waste consists primarily of miscellaneous dry waste and submarine reactor compartments. Parts of two trenches contain transuranic waste.

This RCRA site continued in interim status indicator evaluation in 2000. Upgradient well 299-E34-7 exceeded the critical mean value for specific conductance. The major contributors to the increase are sulfate and calcium. The source of these constituents is not known. However, there is only 0.6 meter (2 feet) of water remaining in this well, which is completed at the top of basalt, and the increase may be related to the basalt chemistry. This well also exceeded the comparison value for total organic carbon in 2000. All results of volatile and semi-volatile organic analyses were less than detection limits except bis (2-ethylhexyl) phthalate at 1.7 μg/L. This does not explain the elevated total organic carbon. Additional investigations are planned.

Low-Level Waste Management Area 3. The 218-W-3A, 218-W-3AE, and 218-W-5 burial grounds in the 200-West Area make up this area. Burial ground 218-W-3A began accepting waste in 1970 and received primarily ion-exchange resins and failed equipment (e.g., tanks, pumps, ovens, agitators, heaters, hoods, vehicles, accessories). Burial ground 218-W-3AE began operating in 1981 and contains low-level and mixed waste, including rags, paper, rubber gloves, tools, and industrial waste. Burial ground 218-W-5 first received waste in 1986, and contains low-level and low-level-mixed waste, including lead bricks and shielding.

This site continued to be monitored under interim status indicator evaluation requirements in 2000. Indicator parameter data from upgradient wells were statistically evaluated, and values from

downgradient wells were compared to values established from the upgradient wells. The critical mean value for specific conductance was exceeded in samples collected from an upgradient well in 2000. The upward trend was noted and reported earlier, and is caused by increases in sulfate and nitrate from upgradient sources. Other contamination indicator parameters were not exceeded in any of the wells monitoring this waste management area.

Several of the groundwater monitoring wells are approaching the point where representative sampling will no longer be possible because of the declining water table. Replacement wells are proposed, but are subject to funding priorities and negotiations with the Washington State Department of Ecology.

Low-Level Waste Management Area 4. This area in the 200-West Area consists of the 218-W-4B and 218-W-4C burial grounds. Burial ground 218-W-4B first received waste in 1968 and contains mixed and retrievable transuranic waste in trenches and caissons. One caisson is believed to contain mixed waste. Waste was first deposited in burial ground 218-W-4C in 1978 and was classified as transuranic, mixed, or low-level and included contaminated soil, decommissioned equipment, and remote-handled transuranic waste.

Indicator parameter data from upgradient wells were statistically evaluated, and values from downgradient wells were compared to values established from the upgradient wells. The critical mean value for total organic halides continued to be exceeded in one downgradient well in 2000. This well used to be an upgradient well, and the exceedance is believed to be caused by carbon tetrachloride from an upgradient source.

7.1.7.5 Liquid Effluent Retention Facility

This facility consists of three lined basins located east of the 200-East Area and serves as

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temporary storage for condensate from the 242-A evaporator. Constituents detected in the effluent stream from the 242-A evaporator were acetone, aluminum, ammonium, 1-butanol, 2-butanone, tritium, strontium-90, ruthenium-106, and cesium-137.

This facility is subject to final status monitoring and is included in the Hanford Site RCRA Permit (Ecology 1994). Groundwater was monitored under the existing interim status plan in 2000 pending regulator approval. In 2000, groundwater monitoring indicated that no dangerous, non-radioactive constituents from the site have entered the groundwater. Specific conductance in two downgradient wells exceeded the critical mean value in 2000. DOE notified the Washington State Department of Ecology of a previous exceedance and submitted a groundwater quality assessment plan and report in 1999. The plan concluded that the Liquid Effluent Retention Facility was not the source of the high specific conductance and detection monitoring should continue.

In 2000, the Liquid Effluent Retention Facility was monitored by one upgradient and two downgradient wells because the other wells went dry in 1999. The water table is dropping below the top of the basalt in the area so there is virtually no unconfined aquifer beneath the facility. In January 2001, another downgradient well went dry and the Washington State Department of Ecology directed DOE to cease statistical evaluation of groundwater data.

7.1.7.6 316-5 Area Process Trenches

These two unlined trenches in the 300 Area were used for the disposal of liquid waste generated in the 300 Area, beginning in 1975, and received uranium and other radioactive and chemical constituents. From 1985 through 1991, the trenches received non-dangerous effluent, and all discharges ceased in 1991.

This site continued to be monitored with a final status corrective-action network in 2000. The objective of groundwater monitoring during the corrective-action period is to monitor the trend of the constituents of concern to determine if they are naturally attenuating, as expected by the CERCLA record of decision for the 300-FF-5 Operable Unit (Record of Decision 1996). A proposed groundwater monitoring plan for corrective action calls for samples from the same wells as in the compliance period, but with fewer independent samples from each well during each sampling period (i.e., four to one). Also, each well showing an exceedance of one of the constituents of concern will be sampled quarterly to better follow the trends of contaminant concentration. The other wells in the network will continue to be sampled semiannually. The proposed plan is being reviewed by the regulator. Until the proposed plan is implemented, the final status compliance monitoring program remains in effect. This plan calls for four independent groundwater samples from each network well (eight) during each semiannual sampling period.

In 2000, uranium and cis-1,2-dichloroethene continued to exceed concentration limits specified in the permit. Uranium and gross alpha exceeded maximum contaminant levels in one or more wells monitoring near the water table. Cis-1,2-dichloroethene exceeded standards in one downgradient well that monitors the base of the unconfined aquifer. DOE reported these data and other monitoring results to the Washington State Department of Ecology via semiannual letter reports.[b]

(b) Letter report, *Resource Conservation and Recovery Act (RCRA) Final Status Corrective Action Semiannual Reports*, from J. G. Morse, U.S. Department of Energy, Richland Operations Office, Richland, Washington, to J. Hedges, Washington State Department of Ecology, Kennewick, Washington, dated November 30, 2000.

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7.1.7.7 Nonradioactive Dangerous Waste Landfill

The Nonradioactive Dangerous Waste Landfill (Central Landfill) in the 600 Area southeast of the 200-East Area received waste from 1975 through 1985 that included asbestos, miscellaneous laboratory waste, solvents, paints, sewage, acids, batteries, and mercury.

This site continued to be monitored under an interim status indicator evaluation program in 2000. Statistical evaluations indicated the site has not adversely affected groundwater quality. However, average values of specific conductance in three downgradient wells are increasing and approaching the critical mean.